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A RECORD FOR STEAM CONSUMPTION has recently been made by the Allis vertical cross-compound engine at the mills of the Warren Mfg. Co., Warren, R. I. The engine was tested shortly after it was started, and showed a steam consumption of 12.59 lbs. per I. HP. per hour. After the engine had been in use some time and all parts had reached a good bearing, another test was made, giving the result of only 12.44 lbs. of steam per I. HP. per hour, on an 18-hour test. The data of the test, as furnished to us by the Edward P. Allis Co., of Milwaukee, the builders of the engine, are as follows:

Engine, cylinders, 32 and 68×60 ins., not jacketed. Clearance, h. p. cyl., 2.13%; l. p. cyl., 1.87%. Receiver filled with reheater tubes.

Duration of test	18 hours.
Steam pressure, by gage	151 lbs. per sq. in.
Vacuum	27 ins. = 13¼ " " "
Revolutions, per minute	76
Average horse-power	1,836 I. HP.
Steam per I. HP. per hour	12.44 lbs.

So far as we know, these results have never before been obtained from an unjacketed compound engine. The best record for a jacketed compound engine, we believe, is that obtained on the Leavitt pumping engine, in Louisville, Ky., in 1894, viz., 12.16 lbs., as reported in the Transactions of the American Society of Mechanical Engineers, Vol. XVI., p. 174.

PEAT-BOGS AS GENERATORS OF ELECTRICAL power are suggested by Dr. Frank in "Stahl und Eisen." He says that the great peat-bogs of North Germany may be thus utilized, and figures that one acre of bog, averaging 10 ft. in thickness, contains about 1,000 tons of dried peat, or 313,000 tons per square mile; and 430 sq. miles would be equivalent in heating power to the 80 to 85 million tons of coal annually mined in Germany. The bogs of the Ems valley alone cover 13,000 sq. miles; and Dr. Frank proposes the erection in that district of a 10,000-HP. electric station, which would yearly consume 200,000 tons of peat, or the product of 200 acres. He would use the electrical energy on the Dortmand & Emshaven canal, and for the manufacture of calcium carbide.

THE GENESEE RIVER DAM BILL, passed by the last session of the New York legislature, has been signed by Governor Black. It provides for the incorporation of a company with power to build a dam for power and other purposes across the Genesee River, a few miles above Rochester. Among the incorporators is Mr. Geo. W. Rafter, M. Am. Soc. C. E., of Rochester.

A MUNICIPAL LIGHTING PLANT FOR TORONTO, Ont., is proposed. The city council has adopted a report from the board of control recommending that the city engineer be instructed to have specifications prepared for a 2-000-HP. plant for lighting the streets and the new city buildings; also that bids be invited for constructing such a plant. The report, as adopted, also recommends that bids be invited for a 6,000-HP. plant for street and electric lighting, bidders to be allowed to bid on their own specifications. The matter is in charge of Mayor Shaw and Aldermen Leslie, Hubbard and Burns. Mr. C. H. Rust is city engineer. We are indebted to Mr. John Blevins, City Clerk, for the above information.

A BRIGADE OF ENGINEERS is being urged by Mr. Eugene Griffin, Vice-President of the General Electric Co., and Mr. W. B. Parsons, M. Am. Soc. C. E., for service in Cuba. The War Department seems to favor such a movement, and Washington reports say that the enlistment of a brigade of that type not exceeding 3,500 in number will be provided for by a special act of Congress. Mr. Griffin served 14 years in the Engineer Corps of the U. S. Army, and has given his reasons in full to Secretary Alger for the formation of a body of regularly enlisted men, composed of civil, mechanical and electrical engineers, mechanics, artisans, draughtsmen, etc. Our late Civil War proved the value of men of this class, and the contemplated occupation of Cuba, with probable siege operations against Havana, will demand the services of an unusually large proportion of engineer troops.

THE SIMS DYNAMITE GUN is being tested by the government at Mattinecock Point, on Long Island. Compressed air is used for throwing the projectile, and it is said that a distance of five miles has been covered by the guns. No details are given out.

HARVEYIZED STEEL ARMOR, to the amount of 7,700 tons, is advertised for, for use on the new battleships "Illinois," "Alabama" and "Wisconsin," now rapidly nearing completion at Newport News, Philadelphia and San Francisco.

THE TROPENAS PROCESS of steel making is shortly to be put in operation on an experimental scale at the works of the Driggs-Seabury Co., at Derby, Conn. The product will be used for projectile manufacture. M. Tropenas is now in this country superintending the installation of the plant at Derby.

A COKE OVEN WITH REMOVABLE BOTTOM is illustrated in the "Iron Trade Review" of April 28. The oven is of the beehive type, and the bottom is carried by four elevating screws which rest on a four-wheeled truck beneath. Information concerning the oven may be obtained from N. B. Taylor, Wilmerding, Pa.

A 17-FT. HYDRAULIC RIVETER for riveting up locomotive boilers, which possesses several novel features, has been constructed by the Baldwin Locomotive Works. The special features of construction are: (1) A cylinder which overhangs the gap, which is made wide enough to allow the fire-box to swing clear on the inside. (2) An automatic squaring device, which, while not exactly a plate closer, works in a somewhat similar manner. It consists of a narrow sleeve surrounding and moving in advance of the die, thus gripping the plate firmly and squaring the work up truly before the upsetting commences. (3) A device by which the power exerted can be instantaneously changed to either 25, 75 or 100 tons. As already stated, the depth of the throat of the riveter is 17 ft. in the clear, the frame being of the horseshoe type and set vertical.

THE MOST SERIOUS RAILWAY ACCIDENT of the week occurred on the Norfolk & Western Ry., about a mile from Bedford City, Va., on May 5. Two freight trains came together in a butting collision, resulting in the death of one fireman and the serious injury of one engineer.

A CAR RAN DOWN AN INCLINE RAILWAY at Thacker, Mingo County, W. Va., on the morning of May 10, owing to the cable breaking. This incline is about a mile long and very steep. Three men were killed and several others injured.

APPLICATIONS OF CANDIDATES for the Graduate Fellowship in Architecture of Cornell University must be filed with the Registrar of the University on or before May 15. Drawings and other credentials are required with the application. The faculty of the College of Architecture also announces a competition for a traveling fellowship of the value of $2,000 to be held in the fall of 1898. This competition is limited to graduates of the College of Architecture under the age of 30 and to special students who shall have completed the two-year special course in architecture. Information concerning the fellowship may be obtained from Prof. A. B. Trowbridge, Ithaca, N. Y.

THE MANHATTAN ELEVATED RY. CO., of New York city, through its President, Mr. Geo. Gould, has replied to the offer of franchises for seven separate extensions of its system which were made by the New York Rapid Transit Commission in March. The Commission offered the franchises at rentals varying from 1% to 5% of the gross earnings of the extensions. The Manhattan Co. in its reply says substantially that it will pay only a nominal rental of one-half of 1% of the gross earnings for any of the extensions, and will construct them on its own terms or not at all. The tone and temper of the letter are such as to make it exceedingly improbable that the company will agree to any terms which the Rapid Transit Commission could consistently offer.

THE DEBT OF THE GREATER NEW YORK, says Comptroller Coler, exceeds its constitutional debt limit by a little over $50,000,000, and $25,000,000 was the excess for the old City of New York. In arriving at these figures in his financial statement to Mayor Van Wyck, Mr. Coler admits that he has included as debts all the contract obligations of the city, some of which cannot fall due for years. He also admits that if the bonded debt alone is reckoned the old city had a margin of about $40,000,000, and the Greater New York a margin of more than $16,000,000. The net bonded debt is $138,000,000; to this Mr. Coler adds $25,000,000 of alleged contract liability, including such items as nearly $2,000,000 for the new Hall of Records, for which the foundation has not been dug. He also adds $37,765,000 for land acquired; though years may elapse before the amount to be paid under this head is fixed by the courts. The late administration claims that this statement is framed for purely partisan purposes, with the view of invalidating contracts made before the present party was in power. It is said that a number of the contractors interested will carry this contention to the Supreme Court; but meanwhile important public works, like the new East River bridge, are being held up for alleged want of funds.

PNEUMATIC TUBE TRANSPORTATION for mails, parcels, etc., Chicago, is proposed by two companies, both of which have applied to the City Council for franchises. The Chicago Air Line Express Co. asks for a 50-year franchise, with the right to lay its pipes underground, on the elevated railways and in the river tunnels. The company will agree to have three miles of line in operation within three years and to pay the city 1% of its gross receipts for five years, 2% for five years and 3% for the remaining forty years. The company has a capital stock of $100,000. Pres., W. C. Walsh Vice.-Pres. and Gen. Mgr., Allan C. Durborow. The Chicago Pneumatic Co. also asks for a 50-year franchise, but makes no mention of putting its pipes on the elevated railways. It will agree to have one mile of line in operation within three years, but offers no compensation for the privileges to be conferred by the franchise. Both companies ask for permission to use either electricity or compressed air.

THE UNION STATION AT OMAHA, Neb., which was commenced in 1890 but never finished, was pulled down and entirely removed in 1897. As noted in our issue of Sept. 3, 1896, the station was being built by a company backed by the Union Pacific Ry. Co. and assisted by the city by means of bonds. When the lower part of the structure was approaching completion the city claimed that the accepted plans were not being adhered to and that certain dimensions had been reduced. This led to disputes, and the city threatened to repudiate the bonds, and the company then stopped work, which was never resumed. The Union Pacific Ry. is still using its old wooden station, and the Burlington & Missouri River R. R. (Burlington System) is now building a new station.

LIGHT RAILWAYS IN PRUSSIA on Oct. 1, 1892, numbered 83, of which 69 were for passenger traffic, 5 for freight and 9 for mixed traffic. The gages were as follows: Ordinary, 37; 3 ft. 3⅜ ins., or one meter gage, 35; 2.46 ft., three; 1.87 ft., one; the rest were of various gages. On 25 of these roads locomotives were used; on six, electricity; on two, cables; on 46, horses, and the others had a mixed service. On July 28, 1892, a law was passed regulating light railways and private lines, and on Sept. 30, 1896, 129 new light railways had been added to the above list, and of these 76 were in actual use and 53 were under construction. Town service was the chief end in view formerly, but owing to the financial support given by the State and public bodies under the new law the bulk of the new lines connected towns for passenger and freight traffic. On 38 of the new lines electricity is used as a motive power. The State of Hanover loans two-thirds of the capital required at 2.65%, and the other third at 3.15%; the Rhine Province loans the money at 3%; and the State of Prussia is authorized to loan $3,250,000 for the building of light railways for agricultural purposes. Their use is rapidly extending, and last year there were 239 projects on foot for lines of this type. Under the law referred to these light roads are under the control of the Post and Telegraph Departments.

A SYSTEM OF TUNNEL VENTILATION on the injector principle has been applied to the Pracchia single-track tunnel, 8,947 ft. long, on the Boulogne & Lucques Railway, in France. The system, devised by Mr. Saccardo, is as follows: At the highest end of the tunnel the mouth is contracted inward in a funnel-shaped form, so as to just admit a train. Immediately at this contraction a lateral tunnel 50 ft. long branches off from one side of the main tunnel. At the mouth of this lateral tunnel is installed a fan which forces air into the tunnel, and with 70 revolutions per minute delivers 3,532 cu. ft. of air per second at a water pressure of 1 in. This air current is directed inward through a second contraction, or funnel, parallel to the one at the entrance and 23 ft. beyond it. In operation the action of the artificial air current is to suck in a considerable volume of outside air, while the air pressure is sufficient to counterbalance the movement of air produced by a train moving at a velocity of 16.4 ft. per second. The system is said to give satisfaction.

COLOR PHOTOGRAPHY; THE JOLY PROCESS.

By J. Stewart Gibson,* Ph. D.

The problem of color photography in the process of its solution has developed several new and most interesting fields of investigation. In fact it has proved itself of a nature far more intricate than was at first anticipated, and it is now known that the exact reproduction of the physical condition, as regards color, is not essential, nor indeed desirable in a picture in order that there may be a truthful representation of the original color to the mind through the eye. Not only the physical nature of light has to be taken into account, but of quite as much importance is the physiological operation performed by the eye in its perception of color.

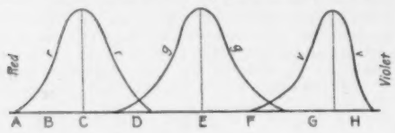


Fig. 1.

Fig. 1.—Curves Representing Narrow Zones of the Spectrum Transmitted by the Several "Viewing Screen" Colors.

It is not necessary to impose the condition of direct transformation of luminous energy into purely physical or molecular motion, according to generally accepted physical theory, for it is well known that the purple fluid of the retina (a delicate chemical compound known as purpurine) is bleached and faded by the action of light, and the complex molecules of this fluid are constantly shattered and broken down in the production of the sensation of sight. It is possible that this decomposition is effected in a certain different and characteristic manner by the long, medium and short waves. In substituting this chemical hypothesis for the physical there is nothing whatever lost, but, on the contrary, the process then becomes strictly analogous to many well-known light transformations, and the eye is truly a photographic camera, not only in its physical structure, but in its chemical action as well, and with the great advantage of not having to replace the film for every new image since the fresh sensitive material is constantly supplied and the old withdrawn without any interruption of the operation of sight. It is understood, of course, that the complete operation of perception of light involves much more than is herein explained, as the theory does not assume to go further than to describe the reception and transformation of luminous energy and thus render a strictly physiological process possible.

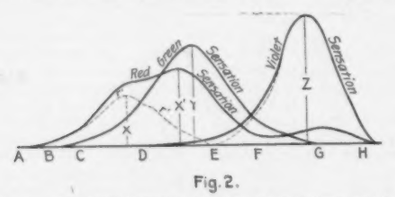


Fig. 2.

Fig. 2.—Koenig's Curves of the Color Sensations and their Modifications for Color Photography.

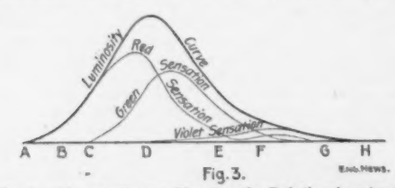


Fig. 3.

Fig. 3.—Abney's Curves Showing the Relative Luminosity of the Spectrum Rays as Regards the Three Fundamental Sensations.

Professor John Joly, of Trinity College, Dublin, is entitled to much credit for having clearly defined the principles involved in the problem of color photography and for having worked out a simple, practical method of applying them, so that any careful amateur can secure for himself most beautiful and accurate results. It is scarcely necessary here to recall the fact that ordinary white light is composed of an infinite variety of wave lengths (in the physical sense), or, if we choose, an infinite variety of colors (in the physiological sense), and that the color of an object results from the kind and number of these components of white light which it does not absorb, and consequently reflects or transmits. This fact once recognized, it is evident that to be able to deal properly with the spectrum, which is nothing more nor less than an orderly analysis of white light, is to be able to deal properly with all color under all conditions. The careful and elaborate investigations of Koenig, Helmholtz, Abney and others have firmly established the tri-chromatic theory of color vision first propounded by Thomas Young. According to this theory the eye presents to the mind the external color reality (regarded as a physical condition), not by handling every hue and tint and shade by itself, but by receiving and perceiving, grouped into three more or less distinct classes, all the endless variety of color presented to it. In other words, the perception of color is realized by an analysis and a subsequent synthesis of the light producing the sensation. This leads up to the first principle employed in this method of color photography, viz.: a photographic analysis of light corresponding to that accomplished by the eye, so that when this analysis is properly presented to the eye it has only to effect the synthesis, and thereby present to the mind what is virtually the same as the original in the physiological sense.

In order to show more definitely the nature of this photographic analysis and physiological synthesis, let Fig. 1 represent a spectrum with the red end at the left and running through to violet at the right; the capital letters indicate Frauenhofer's lines, while the curves marked with the small letters (r), (g) and (v) represent narrow zones of the spectrum with location and color, as shown in the figure. Now it is found that, if from a given spectrum quantities of (r), (g) and (v) light be taken (the amounts being proportioned to the ordinates X, Y, Z, Fig. 2), and distributed upon a white surface, as indicated by the height and range of the broken line curves (including the "green" curve, which remains unaltered) in Fig. 2, the result is, so far as the eye is concerned, a perfect representation of the spectrum. The ordinates of the curves show the distribution of intensity, while the bases indicate the latitude of each of the colors. It must not be supposed the violet is the brightest because its curve is high, for in fact it is the least luminous, and a relatively large amount is required to produce even its proper low luminosity. The curves in Fig. 3 show the relative luminosity of these three fundamental sensations, so called, the heavy curve indicating the relative luminosity of the spectrum as a whole. If, then, the kind and quality and distribution of light is known, which is requisite to faithfully represent to the mind through the eye all the external color quality, it only remains to obtain photographically this particular analysis of light. This is secured by obtaining in three several negatives (Ives), or in three several linear-areas of one linear-structure negative (Joly), taken of the spectrum, deposits of silver, the degree of density and range of which correspond to the broken line curves in Fig. 2. From these negatives positives are made, in which, of course, the degree and range of transparency correspond to these curves. If these positives are backed with material transparent to (r), (g) and (v) color, respectively, and light is projected through them so that the colors are properly superposed (Ives), or juxtaposed (Joly), the analysis is completed and the eye has only to perform the act of synthesis.

The equivalence of juxtaposition and superposition under certain conditions is very interesting and important. It is a well-known fact that the superposition of red and green light is recognized as yellow by the eye; and that similar results occur with other superpositions. The reason for this is quite apparent after a little study of Fig. 2 of the synthesized spectrum. Now the juxtaposing of the same colors will give the same derivatives, providing the juxtaposition is properly made. In the Joly process this is accomplished by placing the colors in very narrow bands side by side. It has been demonstrated that when the three fundamental colors, taken all together, or by twos or singly, in various proportions, are juxtaposed and presented to the eye so that the combination occupies a visual angle of not more than one or two minutes of arc, the colors are synthesized and the complex color sensation produced is the same as that resulting from superposition. There seems to be a definite limit to the fineness of structure of the retina, at least so far as color vision is concerned. The term Retinal Unit has been suggested for this small area within which color vision is homogeneous; and, since the visual angle becomes practically an inscribed angle within the eye, the diameter of the Retinal Unit cannot exceed two or three minutes of arc. A simple computation based on this fact will show that for a transparency viewed at a convenient distance some 400 or more lines per inch will be required in order to synthesize the color perfectly. In showing such a picture with the magic lantern it is evident that these conditions with reference to the visual angle must be observed.

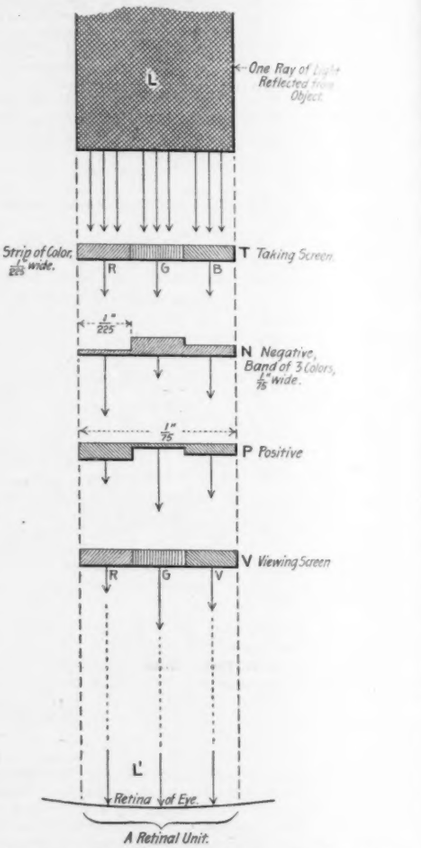


Fig. 4.—Diagram Illustrating the Photographic Action in the Joly Process.

The question is often asked why the colors of the screens by which the photographic analysis is effected, that is, the taking screen colors, are different from the fundamental colors employed in the final synthesis. A glance at Fig. 2 will explain this. Examining the curve (r'), for instance, it is evident that the part of the spectrum engaged in producing the silver deposit in accordance with this curve differs considerably from the zone (r) of Fig. 1. It is, in fact, such a part and amount of the spectrum that, taken as a whole, it appears decidedly orange to the eye. The same explanation applies to the other taking screen colors.

In Fig. 4 the process is represented diagrammatically regarding, for the sake of simplicity, one ray of light reflected from the object to be photographed. This ray (L), which may contain

*36 St. Luke's Place, Montclair, N. J.

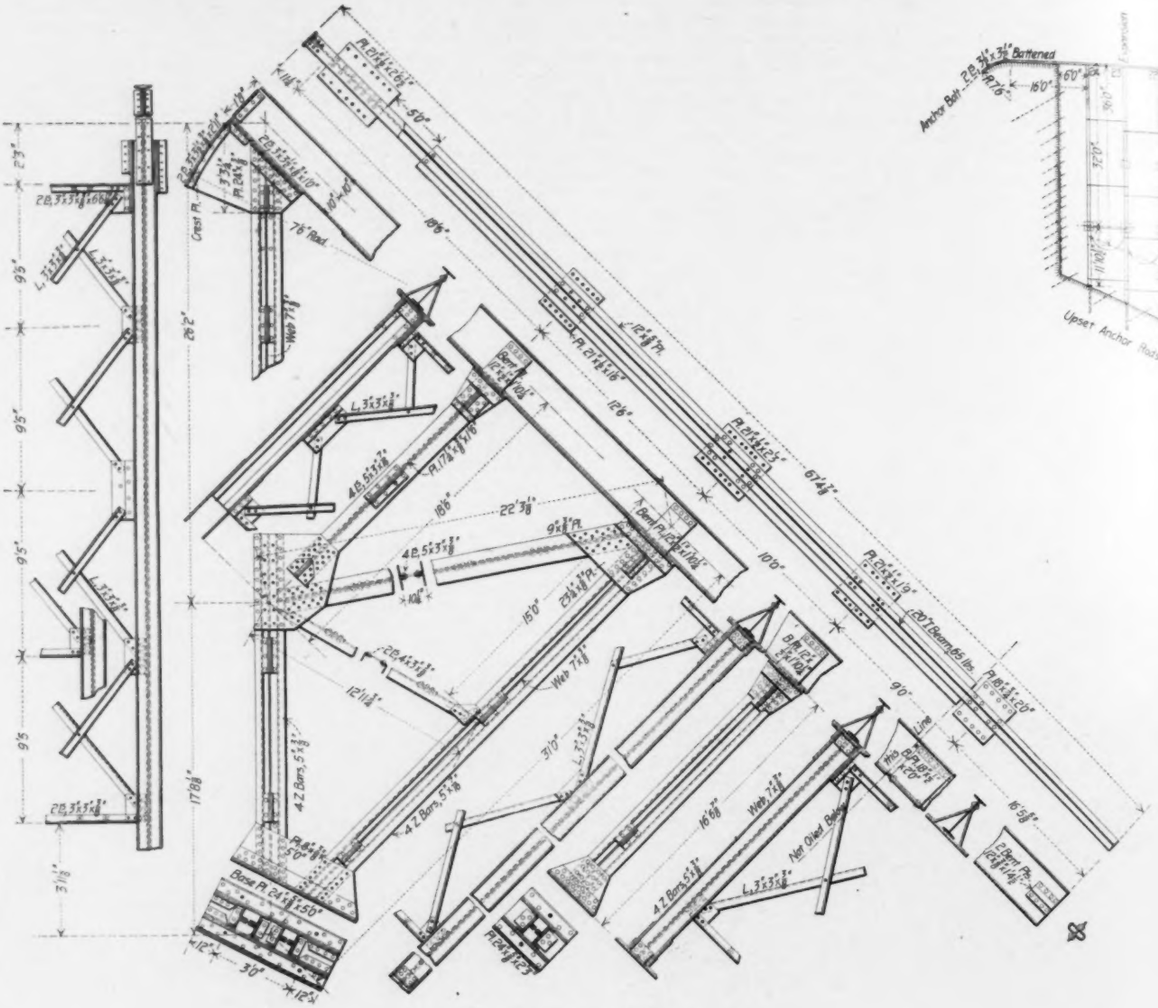


FIG. 3. DETAILS OF BENT NO. 15.

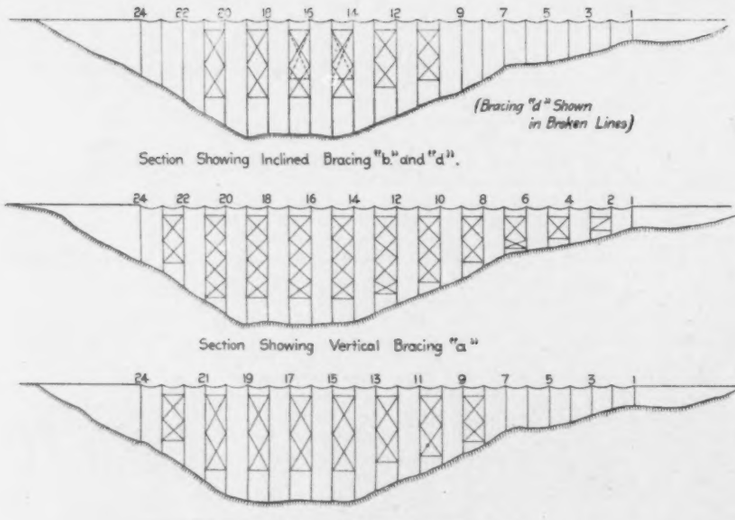
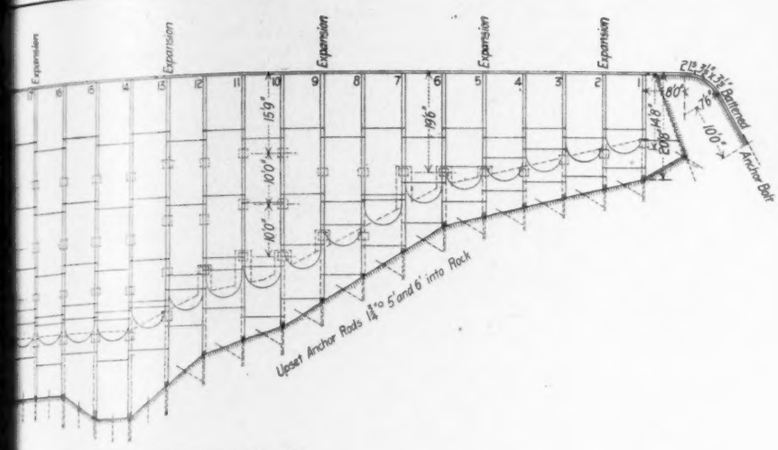

24 22 20 18 16 14 12 9 7 5 3 1
(Bracing "d" Shown in Broken Lines)
Section Showing Inclined Bracing "b" and "d".
24 22 20 18 16 14 12 10 8 6 4 2
Section Showing Vertical Bracing "a"
24 21 19 17 15 13 11 9 7 5 3 1
Section Showing Inclined Bracing "c".

FIG. 4. DIAGRAMS SHOWING LATERAL BRACING.



5. ELEVATION OF UPSTREAM FACE.

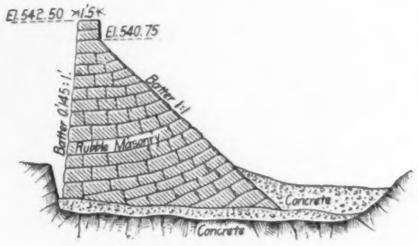


FIG. 7. SECTION OF MASONRY ABUTMENT.

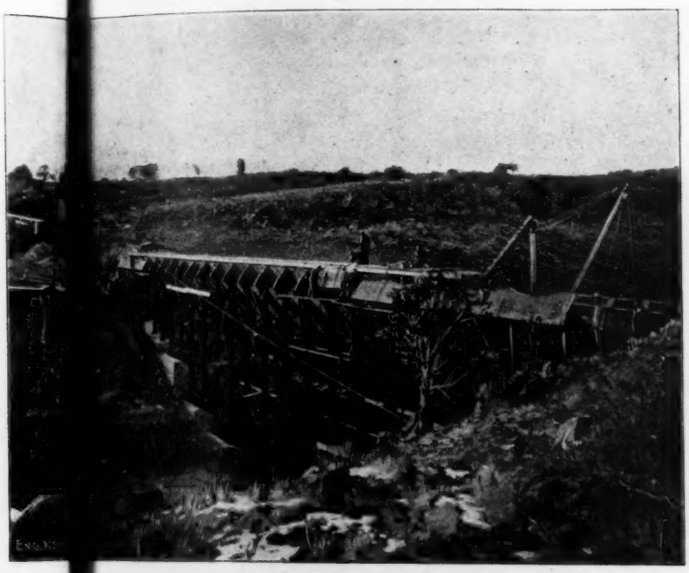


FIG. 1. GENERAL VIEW OF DAM UNDER CONSTRUCTION, FROM DOWNSTREAM SIDE.

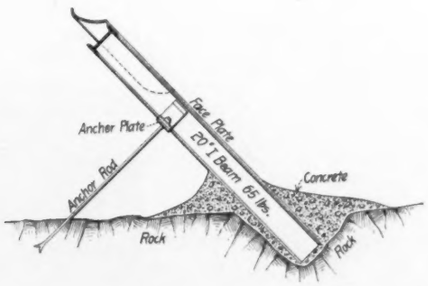


FIG. 6. DETAILS OF TOE, SHOWING CONCRETE JUNCTION TO BED ROCK.

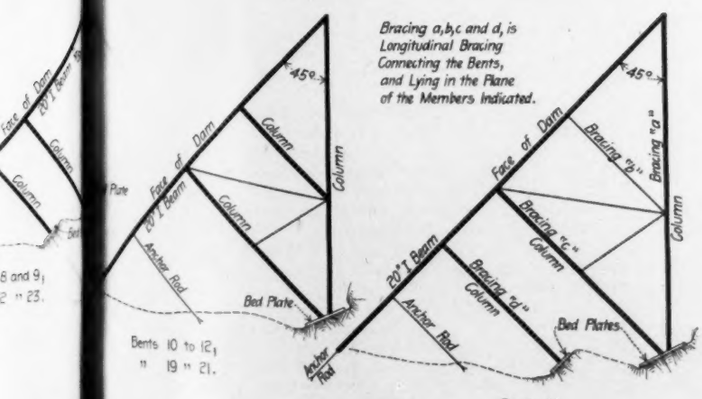


FIG. 2. [illegible] BENTS SUPPORTING UPSTREAM FACE.

STEEL DAM AT ASH FORK, ARIZ., FOR THE ATCHISON, TOPEKA AND SANTA FE RY.

F. H. Bainbridge, Assoc. M. Am. Soc. C. E., Designing Engineer.

Jas. Dun, M. Am Soc. C. E., Chief Engineer, A., T. & S. F. Ry.;

R. B. Burns, Chief Engineer, Santa Fe Pacific Ry.;

W. D. Nicholson, Asst. Engineer in Charge.

The Wisconsin Bridge & Iron Co., Contractors.

any variety of colors, must pass through what is termed the "taking screen" (T) before it can impinge upon the sensitive film of the photographic plate. This screen is made up of tri-color bands 1-75 of an inch in width, the colors used being orange-red, yellowish green, and blue in strips each 1-225 of an inch wide. These color bands are transparent, the one marked (R) transmitting the spectrum rays from infra-red to the E line (green), the color of the collective ray so transmitted being an orange; the band marked (G) transmits from the C line to about the G, the

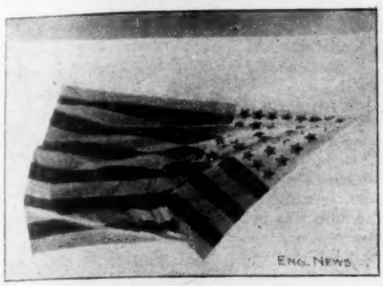


Fig. 5.—Print Showing the Appearance of a Negative Made with a Joly "Taking Screen."

hue of the collective ray so transmitted being, a yellowish-green; while (B) transmits from the E line to ultra-violet, the hue being a blue.

The light, after being thus sorted or filtered, impinges upon the sensitive photographic plate (N), which must be orthochromatic, that is, sensitive to all colors, such a plate, for instance, as is used for spectroscopic work. Here the sensitized gelatine is affected by the different intensities of photographic action, and the resulting densities may be represented, diagrammatically, by the differing thickness of the plate (N). A positive (P) is made from this in the ordinary way in which the densities are reversed and now become transparencies. If we now back this positive with a screen (V), ruled in the same way as the one previously mentioned, except that its colors are the fundamentals (red, green and violet), with red over the area corresponding to (R), the green over the area corresponding to (G), and the violet over that corresponding to (B), the portion of the picture covered by the tri-colored band will show in its original colors. And as the entire plate is covered by a succession of these bands it is evident that the whole object will be pictured in its proper colors.

The practical application of this theory has been reduced to a very simple operation, at least so far as the user is concerned, and all that is necessary is to place the sensitized plate in a plate holder, containing the "taking screen," the film against the ruled surface, and take the picture in the regular way, beginning the development in the dark and finishing with a very little red light A positive is then made and placed upon the viewing screen so that the three several colors upon the viewing screen fall upon the lines of the positive in a certain order corresponding to the order in which these have been derived from the taking screen.

Fig. 5 we have reproduced from a negative taken in the manner described. This brings out quite clearly the appearance of a negative produced by this process. The linear structure is inherent in the nature of the process, but there are very definite limitations, as already shown, under which it is admitted, and these conditions must be carefully regarded. If, however, the photographic manipulations are rightly conducted and the viewing conditions are properly arranged, the conspicuousness of the lines almost, if not entirely, disappears.

Concerning this method as applied in the Joly process it must be acknowledged that it has thus far proved the most practical, that it is based upon strictly scientific principles, and that the results are very satisfactory.

The production of these screens is, of course, an operation requiring a great amount of skill and careful attention to many details, such as temperature of room, purity of materials, freedom from dust, and the like. At present outfits are made consisting of a taking screen, carefully mounted in a special plate holder, a viewing screen, and an orthochromatic screen, consisting of a thin glass, gelatine-coated plate stained with a picric acid solution, which serves to so control the transmissions through the lines as to bring them into proper photographic equality. The taking screen consists of a polished glass plate of the proper size, and about ⅛-in. thick. Upon this plate a transparent gelatine solution, composed of exact proportions of gelatine and distilled water, is poured while the plate is in a horizontal position. The gelatine spreads out over the plate, and after slowly and carefully drying for 24 hours in a room constructed to exclude dust, the plate is ready for ruling. This is done by a special dividing engine in which the prepared plate or plates, as the case may be, are clamped upon a carriage controlled by a feed screw so that it moves 1-225 of an inch for each stroke of the pen carrier, which moves at right angles to the carriage. These pens are ordinary ruling pens, such as are used by draftsmen, except that each one is mounted upon a small horizontal shaft, which in turn rests in notches in the carrier arm. This permits the pen to swing like a pendulum, and trail across the plate as the carrier moves back and forth. At the lower end of each pen, just above the marking point, a small reservoir is attached containing sufficient ink to rule about 60 sq. ins. In order that the inks may dry sufficiently to prevent the colors running and mixing, the pens are spaced a little distance apart. The inks used are made from aniline colors with the greatest care, their exact color being determined by photo-spectroscopic

Fig. 6.—Print Showing the Appearance of a Positive Made from a Joly Negative; Ready for the "Viewing Screen."

methods. After ruling and drying, the plates are carefully varnished to exclude moisture and prevent injury to the lines and then mounted, as already described.

Throughout the entire process the greatest attention is paid to the temperature of the air and its humidity, and it is only possible to successfully rule the screens in this way. Examined under a microscope, these plates present an absolutely uniform series of repeating tri-color bands so nicely ruled that no difference in width nor irregularities of any kind can be detected. The patents controlling the system are owned by the Joly-Sambra Co., whose office and laboratory are located at Montclair, N. J.

STEEL DAM AT ASH FORK, ARIZONA; A., T. & S. F. RY.

(With two-page plate.)

A steel dam in which all pressures and strains are resisted directly by the steel framework is a decided novelty in engineering construction. Several designs have been made for such structures, some of which were considered in connection with the dam for the water power and electric plant of the Pioneer Electric Power Co., near Ogden, Utah, as described in Mr. Goldmark's paper on this plant (Trans. Am. Soc. C. E., May, 1897; Eng. News, March 18 and July 8, 1897). So far as we know, however, only one such dam has been actually built, and that one we describe in the present article. This type of dam must not be confounded with the steel and concrete type described in our issue of March 10, for the latter has only a thin wall of steel, embedded in the concrete heart wall of a rock-fill dam.

In the arid regions passed through by the Atchison, Topeka & Santa Fe Ry. great difficulty and expense have been incurred in procuring and hauling water for the locomotives and stations, and about two years ago the company decided to establish large reservoirs by damming up some of the valleys and canyons. These reservoirs would retain the water of the winter rains and storms and thus provide an abundant supply during the dry seasons. Three of these reservoirs have been established in Arizona, two of which are formed by masonry dams, and the third by a steel dam, the later being near the town of Ash Fork.

The Ash Fork dam is situated four miles east of Ash Fork, a station on the Santa Fe Pacific Ry. (A. T. & S. F. Ry. system) and the northern terminus of the Santa Fe, Prescott & Phoenix Ry. It is located in Johnson's canyon, which is known as a dry canyon, having running water only twice a year, from February to May, and again in July and August. Previous to the establishment of this reservoir, water was brought by rail from Williams, 23 miles away, and at times from Bellemont, 45 miles distant. The reservoir was established mainly for the purpose of supplying the engines of the Santa Fe Pacific Ry., and incidentally for supplying the town of Ash Fork and the engines of the Santa Fe, Prescott & Phoenix Ry. The average consumption is estimated at 90,000 gallons per day. The reservoir has a capacity of 36,000,000 gallons, taking the flow from a drainage area of about 26 sq. miles, and it is believed that the evaporation will amount to about 9 ft. per year.

The steel dam is 184 ft. long on top, and about 300 ft. in total length, if a short concrete abutment at each end is included. Its greatest height is 46 ft. Structurally it consists of a series of triangular steel bents or frames, resting on concrete foundations and carrying steel face plates on the inclined or upstream face of the bents. At the dam site there is an exposure of an extremely hard igneous rock, except on the west side of the canyon, where it is covered with soil from a few inches to 3 ft. in depth. Natural cinder pockets were uncovered at the site of the west abutment, and under the crest of the dam between bents 16 and 20. Along the whole length of the water toe of the dam the rock was continuous but badly broken by seams, while between bents 14 and 15 was a hole which had been originally a cinder pocket, but when uncovered was found to be filled with large boulders. These boulders were partly removed and the hole was filled in with concrete. Elsewhere along the water toe the rock was generally removed to a depth of 2 ft., but to a greater depth where the rock was specially loose and seamy.

The foundations for the steel bents are of concrete, composed of 1 part of Alpha Portland cement to 3 parts of sand and 5 parts of broken stone. The stone used was the excavated rock, broken up by hand hammers. The foundations for the vertical and the inclined posts were built before the iron work was erected. The vertical posts rest on concrete walls, and the higher walls are faced with rubble masonry on the side facing the canyon, as may be seen in the view, Fig. 1. The outlet is a 6-in. pipe bedded in concrete in a trench excavated in the rock under the dam, the pipe terminating in a drain within the reservoir. From the downstream end of this pipe a 4-in. pipe line extends to Ash Fork, four miles distant.

A notable feature of this structure is that there is no spillway or waste weir, the dam being designed to safely permit a flow of 6 ft. deep over its crest, which is believed to be greater than will ever be experienced. There is but little drift, and few logs are likely to be brought down, so that there is no fear of damage to the crest of the dam.

What provision, if any, it is designed to make to protect the rock under the over-fall from erosion by the falling sheet of water we are not informed. A simple timber apron, however, would doubtless meet all requirements, and it may even be that the flow over the crest will occur so seldom that the rock can take the wear without danger.

A general view of the dam, from the downstream side, is given in Fig. 1, which shows some of the men putting on the convex crest plates, which are cut out on the upper side to fit the concave face plates.

As already noted, the dam consists of a series of 24 triangular bents. These bents are right-angled triangles, with the inclined side, having a slope of 45°, facing upstream, and the rocky bottom of the canyon forming the base. The dimensions of the bents vary with their height. The end bents (Nos. 1 to 7 and No. 24) are 12 to 21 ft. in height, each consisting of a vertical Z-bar column and an inclined I-beam. Bents Nos. 8, 9, 22 and 23 are about 33 ft. high. Each has a vertical Z-bar column, an inclined I-beam, and two inclined posts or columns built up of Z-bars, the upper of these resting on the same shoe or bed plate as the vertical post. Bents Nos. 10, 11, 12, 19, 20 and 21 are 33 ft. to 41 ft. 10 ins. high. These have but one inclined post, which rests on the same bed plate as the vertical post, while above it are truss members connecting the face member with the posts. Bents Nos. 13 to 18, inclusive, are 36 ft. to 41 ft. 10 ins. high, and have two inclined posts, with truss members above the upper post. The general designs of these four styles of bents are shown in Fig. 2. In all of them the face is composed of a 20-in. 65-lb. I-beam, reinforced on the underside by a plate ½-in. thick and 18 ins. wide. The vertical and inclined posts are all composed of four Z-bars and a web plate.

The details of bent No. 15 are shown in Fig. 3. In this bent the vertical post is composed of four Z-bars ⅝ × 5 × 3 ins., and a web plate ⅝ × 7 ins. The top is spliced to the upper end of the inclined 20-in. I-beam, while the lower end rests in a shoe on the masonry. This shoe also carries the end of the upper inclined post, which is composed of four Z-bars 7-16 × 5 × 3 ins., and a web plate ⅝ × 7 ins. The truss members above this post are built up of two or four angles ⅝ × 5 × 3 ins., to form I-beam or channel sections, and large connection plates are used where these are attached to the main members. The lower inclined post is of similar construction to the upper one. At the lower end of the inclined I-beam are two bent plates or straps to hold the anchor bolts which are parallel with the center line of the beam and are let into the rock. About 16-ft. up from the end of the beam is an anchor plate ¾ × 18 x 24 ins., stiffened by two bent plates against the beam. The plate has two holes 2 ins. diameter for the rear anchor bolts, which are at right angles to the face, and are let 2 ft. into the rock. There are 232 soft-steel anchor rods in all, upset and threaded at one end, and split for 6 ins. at the lower end for 4-in. steel wedges ¾-in. thick at the base and 1½ ins. wide. Of these rods 142 are 1½ ins. diameter, upset to 1⅞ ins., and from 1 ft. to 18 ft. 2½ ins. long; while 90 are 1¾ ins. diameter, upset to 2⅛ ins., and from 6 ft. 10 ins. to 14 ft. 2¾ ins. long.

The bents are connected by four sets of transverse diagonal bracing, between the vertical and inclined posts, as shown in the drawing of bent No. 14, in Fig. 2, and the general arrangement of these sets of bracing is shown in Fig. 4. The bracing is composed of single or double angle irons, ⅝ × 3 × 3 ins., the ends of which are riveted to connection plates.

The structure is composed of alternate rigid and loose panels. The crest or apron plates which fit the braced panels between the bents are riveted to a curved angle which is riveted to the upper end of the curved plate, while in the unbraced panels this curved angle merely bears on the apron plate. Longitudinal expansion would be fatal to a structure of this character and the means provided by Mr. Bainbridge to avoid this form one of the original features of the design.

An elevation of the dam, on its upstream side, is shown in Fig. 5. The face of the dam is composed of steel plates ⅜-in. thick and 8 ft. 10⅝ ins. wide, riveted to the outer flanges of the I-beams of the bents. The plates are mainly 8 ft. in length. They are curved transversely to a radius of 7 ft. 6 ins., forming a series of gullies or channels down the face, the width of the channels being 7 ft. 5 ins. measured on the chord, leaving at each side a flat portion which rests on and is riveted to the I-beams. The curved plates, however, do not extend into the concrete of the toe, but are replaced by flat plates in the bottom course, the bottom curved plate being dished to a radius of 3 ft. 8½ ins., forming a segment of a sphere. This arrangement will be seen by the curved lines near the bottom of the dam in Fig. 5. The plates outside of bent No. 1 are flat, and are let into the concrete of the abutment. Those beyond bent No. 24 are also flat, and are fitted with bent plates or stirrups for anchor rods let into the face of the rocky bluff, as shown in Fig. 5. There are seven expansion joints, most of them being at intervals of five bents. The shop rivets are of soft steel, and all hand-driven rivets exposed to water pressure are of wrought-iron. Rivet holes are punched ⅛-in. less in diameter than the size required, and then reamed to size. The edges of the plates and of their splices are planed to a bevel edge for calking. The material was specified to meet the requirements and tests of the railway company's standard specifications for metal bridges.

At the toe of the dam it was proposed to cut deep into the rock and let the I-beam into the trench, filling it up level with concrete. Owing, however, to the possibility of uncovering cinder pockets like those already described, it was decided to cut into the rock as little as possible, and the normal depth of trench, therefore, was only 2 ft., increased where the loose and seamy character of the rock required more excavation. A toe wall of concrete was then built along the line of the trench, covering the ends of the beams and the face plates. The details of the construction of the toe are shown in Fig. 6.

As already noted, the dam is designed as an overflow dam, and its top is fitted with curved crest plates, projecting on the downstream side. The tops of these plates are cut out to fit the curve of the face plates. At each end of the dam is a masonry abutment, to which the top of the steel framework is anchored by a pair of angles, 3½ × 3½ ins., connected by bottom plates. The outer end of each horizontal anchor is curved to a radius of 7 ft. 6 ins. and attached to an end anchor bolt. The face of the abutment has the same slope as the face of the steelwork, but projects 8 ins. in front of the steel face. The form of the masonry abutment is shown in Fig. 7.

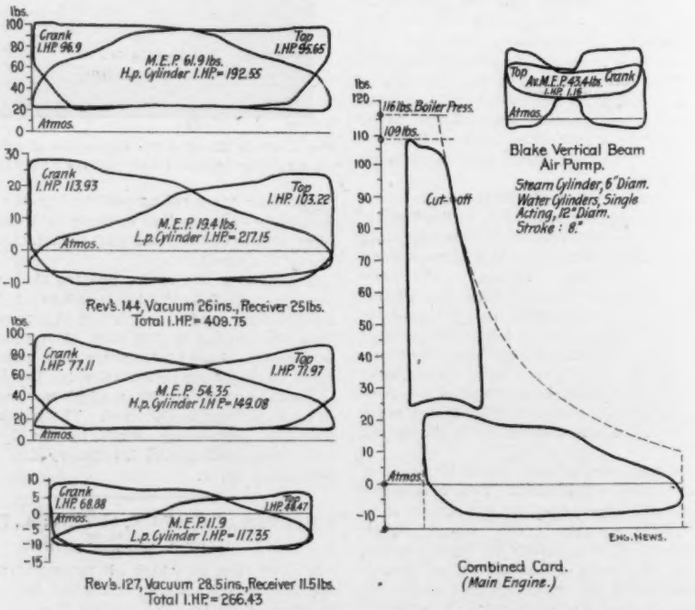
The framework of the bents was first erected complete, only such face plates being bolted on as were necessary to ensure the proper spacing of the bents. The various members were blocked up in position in such a way as to allow free access for embedding their ends in concrete where required, and for the drilling of the holes for the anchor bolts by the railway company. When the framework was erected and the bolts were set, the face plates were riveted on, except the lowest course of plates in the five highest panels of the dam, which were left open to provide a waterway until the rest of the structure was calked and painted, and the dam in proper condition to stand water pressure. The remaining plates were then put in place, riveted up and calked as rapidly as possible. The specifications provided that all joints exposed to water pressure should be calked with round-pointed calking tools on the water face, so as to be watertight under the maximum hydraulic pressure, and that provision should be made for calking the face joints on the rear or under side in case of any leaks developing.

The metalwork, except the face plates, was given one coat of raw linseed oil at the shops, this coating being omitted, however, on all parts to be embedded in concrete. The face plates were not oiled or painted, but after erection they were cleaned of all rust, dirt and grease, and then covered with a coat of graphite paint. The painting was interfered with, however, by a sudden rise of the water while the final riveting was in progress.

The dam was proposed by Mr. F. H. Bainbridge, Assoc. M. Am. Soc. C. E., of Chicago, and was designed by him under the direction of Mr. James Dun, M. Am. Soc. C. E., Chief Engineer of the Atchison, Topeka & Santa Fe Ry. The work was done under the supervision of Mr. R. B. Burns, Chief Engineer of the Santa Fe Pacific Ry., Mr. W. D. Nicholson, Assistant Engineer, being in direct charge. The Wisconsin Bridge & Iron Co., of Milwaukee, Wis., had the contract for the construction ad erection of the iron work. The excavation, concrete and masonry work, anchorages and outlet were all executed by the railway company.

TESTS OF THE FIRE BOAT "ROBERT A. VAN WYCK."

We are indebted to Mr. H. de B. Parsons, M. Am. Soc. M. E., for the data given below, relating to the dimension, trials, etc., of the new fire boat "Robert A. Van Wyck," which was designed by him for the Fire Department of the city of New York. The hull and machinery were built by John H. Dialogue & Son, Camden, N. J., and the fire pumps by the American Fire Engine Co., Seneca Falls, N. Y. The contract for the boat was signed on May 21, 1897, work was commenced May 29, and the boat was launched Nov. 27. She was then called the "William L. Strong," after the then mayor of the city, but when the consolidation of the "greater city" and the inauguration of Mayor Van Wyck took place the boat's name was changed. The trials were made on the Delaware River, in fresh water, on March 9 and 10,



INDICATOR CARDS FROM ENGINES OF FIRE BOAT "ROBERT A. VAN WYCK."

1898, and the boat was delivered in New York on April 7. The data are as follows:

Hull.

Material	Steel.
Length over all	110 ft. 10 ins.
" on load water line	102 " 0 "
" between perpendiculars	97 " 6 "
Beam	24 " 0 "
Draft, all weights on board	9 " 0 "
Displacement, load water line	306.8 tons.
Displacement, per inch at load water line	4.3 "
Block coefficient, between perpendiculars and base	0.539
Prismatic coefficient, between perpendiculars and base	0.658
Transverse meta-center, above C. G.	2 ft. 5 ins.
Longitudinal meta-center, above C. G.	107 " 0 "
Center of buoyancy, below load water line	3 " 6 "
" aft of stem	50 " 8 "
" gravity, above load water line	0 " 9 "
Moment to alter trim 1 in.	27.9 ft.-tons.
Propeller, 4 blades; diam., 7 ft. ½-in.; ave. pitch, 10.50 ft.	

Boilers.

Number	Two; Type Scotch.
Diameter	10 ft. 1⅜ ins. Length over all 11 ft. ½-in.
Number of furnaces	Two ("Morrison" suspension).
Diameter of furnaces, mean	38⅞ ins.
Number of 3-in. tubes, each boiler	132
Grate surface, both	77 sq. ft.
Heating surface, both	2,100 "
Weight, empty, each	32,100 lbs.
" water, each	22,050 "
" full, each, including fixtures	58,850 "

Engine.

Type	Single screw, inverted fore and aft, compound.
Length of stroke	22 ins.
Diameter, h. p. cylinder	16 "
" l. p. cylinder	30 "

Fire Pumps.

Two sets of simple, direct-acting duplex, crank and flywheel.

Each steam cylinder, diameter	17 ins.
" water " "	10 "
Common stroke	11 "

Log of Trials.—Pumps.

Date, March 9 and 10, 1898.

	Port.	Starboard.
Revolutions	226	228½
Steam pressure	114½	119
Water pressure at pumps	175½	191
" discharged, gallons per minute	3,177	3,212

Trial Run.—Delaware River (fresh water).

	Time. h. m. s.	Distance, Stat. mls.
Left ship-yard, Camden, N. J.	10:45:00	.....
Passed Marcus Hook, dock	12:31:15	18.75
" Christiana Creek, light-house	1:19:30	8.625
Return—Passed Christiana Crk, light-h.	1:20:30	.....
" " Marcus Hook, dock	1:57:35	8.625
Off shipyard	3:20:00	18.75
Duration of trial	4:35:00	.....
Draft of water on trial, forward	7 ft. 9 ins.	
" " " aft	9 " 2 "	
Displacement on trial	279.5 tons.	
Wetted surface	2,915 sq. ft.	
Av. speed—Marcus H'k and Christiana Cr'k, mls per hr.	12.32	
I. HP. main engine for above speed	391.10	
" " per 100 sq. ft. wetted surface	13.42	
" " reduced to 10 knots	10.92	
Revolutions per minute	143	
Slip of propeller	28%	
I. HP. for full trial—h. p. cylinder	175.72	
" " l. p. "	154.52	
" " total, main engine	330.24	
" " air pumps	1.05	
" " circulating pump, estimated	4.80	
" " feed pump	1.60	
" " total for all machinery	337.69	
Average revolutions, main engines	124 per min.	
" steam pressure at boilers	116 lbs.	
" " " at receiver	23.8"	
" vacuum	26 ins.	
Total coal burned (bituminous; run of mine)	5,075 lbs.	
" ash	242 "	
Moisture in steam	0.12%	
Temperature of feed water, average	84° F.	
Coal per total I. HP. per hour	3.34 lbs.	
" sq. ft. grate per hour	14.7 "	
Water evaporated per lb. coal	8 57 "	
" " combustible	9.0 "	
" pr hr., sq. ft. h't'g surface	4.60 "	
Steam, dry, per HP. hour, main engine	24.7 "	
" " all machinery	28.5 "	
Steam used by main engine by difference	36,747.7 "	
" air pump, estimated	411.0 "	
" feed pump, estimated	320.0 "	
" circulating engine, estimated	252.0 "	
" safety valves, estimated	5,540.0 "	
" steering engine, estimated	200 0 "	
Priming, as measured	49.3 "	
Feed water, by meter	43,520 "	

Note.—The fire pumps discharged, both before and after the trial, more water than here shown.

RELEASING DEVICE FOR INTERLOCKING PLANTS.

In a small interlocking plant recently installed for the Chicago & Northwestern Ry., at the junction of that road and the Chicago, Burlington & Quincy R. R., at East Clinton, Ill., a new and interesting form of mechanical release for the electric locks has been introduced by the National Switch & Signal Co., of Easton, Pa., which company installed the plant. This device is the invention of Mr. Henry M. Sperry, Signal Engineer and Western Agent of the company. The tower contains a lever frame for 16 levers, divided as follows:

Levers for 7 switches and 5 switch locks	4
Levers for 2 facing point locks	1
Levers for 8 signals	6
Total working levers	11
Spare spaces	5
Total	16

In this plant there is the usual provision of electric locking which prevents the towerman from changing a route already set, after the train has entered the limits of the interlocking, as he might do in a moment of excitement or carelessness. This eliminates the danger incident to the route being suddenly changed in front of a fast train, but in order to prevent delay and complication it is necessary to provide for the possibility of a train which has received a clear signal stopping before it reaches the crossing or junction. Without some means of releasing the electric locks this would tie up the whole plant, as the signals, switches and derails of the other route could not then be cleared. This difficulty is usually provided for by an electric releasing switch enclosed in a box having a glass face, the towerman having to break the glass in order to effect the release, and being required to report upon every case in which he does this. This operation, however, is very quickly effected, and a sleepy or excited man may hastily break the glass and effect the release without stopping to consider the circumstances of the case.

The special object of Mr. Sperry's device is to introduce the element of time, and make it a somewhat lengthy task to release the lock, thereby compelling the towerman to give some time and attention to the operation. Fig. 1 is an elevation of the locking plant, as arranged for a single track grade crossing, and Fig. 2 is an interior view of the East Clinton tower, showing the hand wheel of the release at the left hand end of the lever frame.

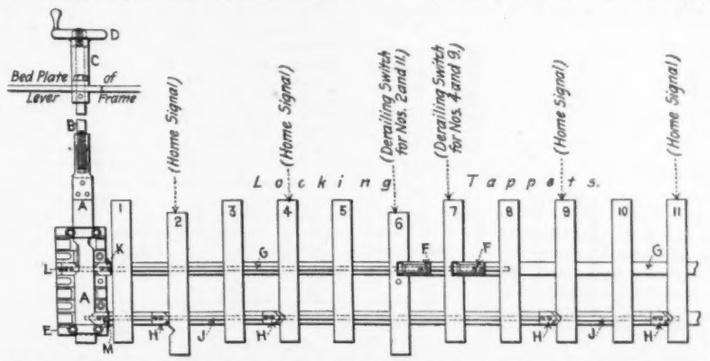


FIG. 1.—INTERLOCKING PLANT FITTED WITH HAND RELEASE FOR THE ELECTRIC LOCKS.

In Fig. 1 the tappets are numbered 1 to 11, and at the left hand is an extra tappet, A, operated by the threaded end of the rod, B. This rod passes up through a guide, C, bolted to the lever frame on the floor of the tower, and is revolved by the hand wheel, D. It takes 25 turns of the hand wheel to raise the tappet through a distance of 2½ ins. The tappet has notches to fit the locking dogs, and works vertically in a portion of the interlocking frame, E. Two electric locks are used, on tappets No. 6 and No. 7, which are the tappets connected with the levers of the derailing switches, and at the right of the plunger for these locks are two releasing dogs, F, F, attached to the locking rod, G. Each of these dogs has its left end shaped as a wedge, so that when moved to the left it will push in the armature lever to the electric lock, this action then withdrawing the bolt which locks tappet No. 6. The tappets Nos. 2, 4, 9 and 11 have notches which engage the locking dogs H, H, H, H, attached to the locking bar, J. These tappets are connected with the home signal levers.

When the towerman wishes to release the locks in order to change the route, he must first of all set the cleared home signal at danger, thus raising the tappet No. 2 so that all the tappets of the home signal levers have their notches in line. He then turns the hand wheel, D, and as the tappet, A, begins to raise it forces the locking rod, J, and dogs, H, to the right, locking the home signal levers Nos. 2, 4, 9 and 11. When near the end of its travel, the lower right-hand notch of the tappet, A, comes opposite the dog, K, and at the end of its travel it forces the dog, L, to the left, and presents the blank edge to the dog, M, thus preventing the unlocking of the home signal levers and the clearing of any one of these signals. As the dog, L, is forced over to the left it pulls over the releasing dogs, F, F, which in turn withdraw the plunger of the electric lock, as above described.

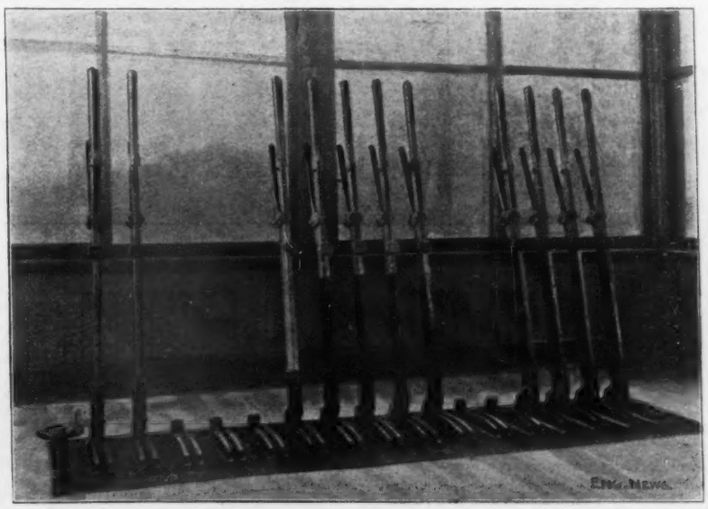


FIG. 2.—INTERIOR OF SIGNAL TOWER AT EAST CLINTON, ILL., C. & N. W. RY.
(Showing Hand Wheel of Release for Electric Locks.)

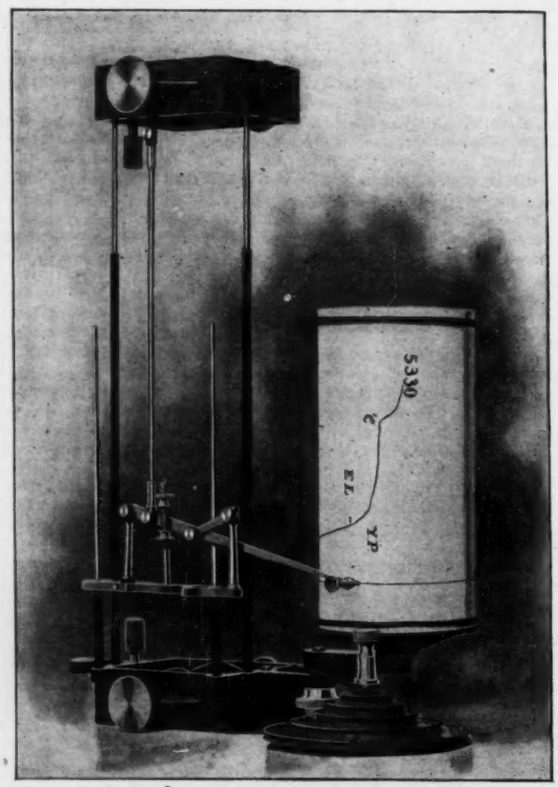
When the tappet, A, is thus raised and the above operations have been effected, the derailing switch lever No. 6 can be thrown to its normal position (with switch open). The opposing route

can then be cleared by throwing the other derailing switch lever No. 7, and closing that switch. The hand wheel is then reversed, and as the tappet, A, travels downward, the derailing switch lever No. 7 is automatically locked in its new position (with switch closed) by the plunger of the electric lock, which falls into place by gravity. This being done, the tappets Nos. 4 and 9, of the home signals, can be cleared, Nos. 2 and 11 remaining closed. The release of the derailing switch lever can be effected in this way, whether it was locked by the circuit-breaker on the home signal circuit, or by the failure of the releasing circuit, but it will be noted that all home signals must be set at danger before the release can be effected.

A POCKET RECORDER FOR TESTING MATERIALS.

In our issue of June 3, 1897, we illustrated and described the Pocket Recorder invented by Mr. Gus. C. Henning, M. Am. Soc. M. E., a portable instrument used for obtaining stress strain diagrams of materials under test in the usual forms of testing machines. It will be remembered that this instrument is attached to the test piece directly, remaining on it until the instant of rupture, thereby insuring a complete record of the test.

Since the article referred to was published, the instrument has been modified and simplified in several respects, and the illustration here given represents it in its present form. The parallel motion now multiplies 10 times instead of 5 times, as originally constructed. It will be noticed that the revolving drum has been provided with a knurled rim which meshes accurately into a small knurled nut on a vertical spindle carrying a cone pulley at its lower end. This pulley is carried by a swinging arm so arranged that its position can be changed. A counterweight string attached to the weighing device is passed around one of the grooves in this pulley. As this string unwinds the drum revolves with a uniform velocity, since the cord tension is constant. Owing to the fact that the weight on a lever machine travels proportionately to the load applied, and the section of the test piece, the card would vary considerably in length and appear distorted. This is corrected, and a fairly uniform length of diagram is produced by selecting the proper groove on the pulley, thus reducing on the card the travel of the poise. This cone pulley reduces 2, 3, 4, 5 and 6 times, respectively, according to the groove used. It is placed below the knurled nut and can be shifted to either side of the drum, thus insuring a straight pull and a close contact between the nut and drum.



HENNING'S RECORDING EXTENSOMETER.

Recently bending, shearing and punching tests have been recorded by the instrument, and while the travel of the poise was used to actuate the drum in the first case, in the latter the spring of the machines themselves was utilized. As it has been repeatedly demonstrated that the spring of the machines was strictly proportional to the loads applied, it serves admirably as a means for actuating the device.

The instrument is provided with three sets of rods for 8, 10 and 12-in. gage lengths, and it will be seen that it has a very wide range of application, also that it is not alone intended for the physical laboratory, but is essentially a shop apparatus for determining the qualities of materials in a simple and practical manner.

THE NEW EAST RIVER BRIDGE COMMISSIONERS will receive $200,000 from the Board of Estimate of New York. This is only a fraction of the amount needed to push the work, and is appropriated to prevent the deterioration of or damage to work already commenced.

RECENT TRIALS OF THE CRUISER "DIADEM."*

By Sir John Durston, K. C. B., R. N.**

The author had the honor in April last to submit to the Institution some notes on the trials of the cruisers "Powerful" and "Terrible," the first ships in our navy of large power fitted with water-tube boilers of the Belleville or large tube type, and the present paper respecting the trials of the cruiser "Diadem" is submitted as a supplement or a continuation of those notes.

While the boilers of the first four vessels of the "Diadem" class were under construction, trials at Paris of Belleville boilers fitted with economizers showed considerable advantages over the "Powerful" type of boiler, in economy of fuel, less tendency to production of smoke, and lower funnel temperatures. Consequently, it was decided to alter the boilers of the vessels of this class by reducing the number of generator tubes, and fitting economizers as shown in the engravings herewith.

Comparing the section of the boilers of the "Diadem" with that of the "Powerful" type of boiler, it will be seen that the number of rows of 4½-in. generating tubes in each element has been reduced from ten to seven, while over the generating tubes there is a space provided corresponding to that of the combustion chamber in an ordinary return tube cylindrical boiler, and above this space is situated another nest of tubes of smaller—2¾ ins.—diameter, and seven rows in height, forming the economizer. The furnace air-blowing engines supply jets of air to this space as well as into the furnaces below. The feed-water is pumped into the lower part of the economizer, traverses to the top of its elements, and from thence it is led to the steam collector for feeding the generating tubes.

The advantages of this arrangement are that the combustion is more effectually completed, the escaping funnel gases are of a much lower temperature, firing does not require so much attention, and a considerable economy in fuels is obtained.

The machinery of the "Diadem" class is designed to attain a maximum power of 16,500 I. HP., and a continuous sea-going power of 12,500 I. HP. for as long as the coal lasts.

The special trials were: (1) An eight hours' trial at 16,500 I. HP., with all boilers in use; (2) a thirty hours' trial at 12,500 I. HP., with all boilers in use; and (3) a 30 hours' trial at 3,300 I. HP., with the number of boilers at discretion of contractor. Only the after set of eight boilers, or 27% of the total boiler capacity, was actually used. The maximum pressure at which the engines were specified to work was 250 lbs. per sq. in., with a boiler pressure of 300 lbs., an increase of 40 lbs. beyond that specified for the "Powerful" and "Terrible." The engines are of the four-cylinder triple-expansion type. The diameters of the cylinders are as follows: High-pressure, 34 ins.; intermedite-pressure, 55½ ins.; two low-pressure, each 64 ins.

The stroke is 4 ft., with a designed cut-off in the high-pressure cylinder of 73%. Allowing for a clearance in the high-pressure cylinder of 25%, and in the low-pressure cylinder of 15%, the designed real ratio of expansion at full power was about 8.3. The cylinders are arranged with the high-pressure cylinder forward, and the two low-pressure cylinders aft. The two low-pressure cranks are opposite each other, and the high-pressure and intermediate-pressure cranks also opposite each other, but at right angles to the low-pressure cranks. All the cylinders are steam-jacketed, those of the intermediate-pressure and low-pressure cylinders only were used on the trials, the pressure maintained in the jackets being regulated to approximately equal their respective receiver pressures.

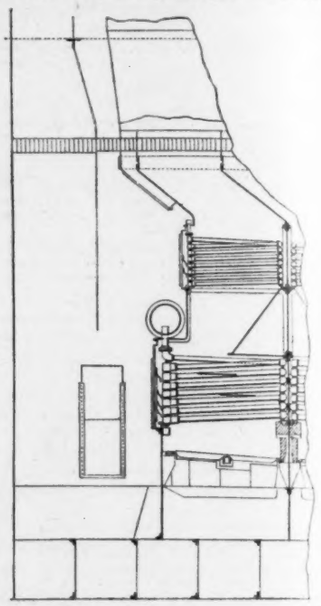


Fig. 1.—Section Through Belleville Boilers of British Cruiser, "Diadem."

The boilers are 30 in number, arranged in four compartments, with tubes fore and aft, eight in each of the three after and six in the forward one, placed back to back in each compartment. The gases are led into four funnels, and the uptake leads from the boilers are practically vertical. Each boiler compartment has a separate main steam pipe and feed system, the four main steam pipes being carried to the forward bulkhead of engine-room, with the usual stop valve to each pipe at the bulkhead. The total heating surface of the boilers as originally designed was 42,270 sq. ft., or 2.56 sq. ft. per I. HP. After the boilers were modified the heating surface in the generator portion was reduced to 29,600 sq. ft., or 1.8 sq. ft. per I. HP.; while in the economizers an addition was made of 10,950 sq. ft., or 66 sq. ft. per I. HP., making a total surface of 40,550 sq. ft., or 2.46 sq. ft. per maximum specified I. HP.

The usual stokehold fans, necessary to insure a constant supply of air from the upper deck in all circumstances, and air-blowing engines for the purpose of supplying air in jets to mix the furnace and combustion chamber gases and assist the combustion, are fitted. Table A gives the results of all the trials carried out. The first trial was the contract 30 hours' trial at 3,300 I. HP., i. e., one-fifth the designed maximum power, and the results are given in column. Eight boilers were used, the mean power being 3,318, the coal consumption per I. HP. per hour being 2.18, or 18.4 lbs. per sq. ft. of grate per hour. During this

The table following shows the disposition of heating surfaces, and the total weights in representative eight-element boilers in "Powerful" and "Diadem" respectively:

One Boiler.

	Ship. "Powerful."	Ship. "Diadem."
Number of elements: Generator	8	8
Economizer	0	6
Heating surface: Generator, sq ft.	1,420	995
Economizer, sq. ft.	....	355
Total	1,420	1,350
Fire grate, sq. ft.	49	49
Weight of boiler, tons*	17.4	16.7
Weight of water, tons	1.1	1.3
Total weight, tons	18.5	18

*With furnace, fittings, castings, lagging and mountings complete.

*Condensed from a paper read at the thirty-ninth session of the Institution of Naval Architects, March, 1898.
**Engineer in Chief of H. M. Navy.

TABLE A.—MEAN RESULTS OF THE TRIALS OF THE BRITISH CRUISER "DIADEM," AND TWO VESSELS WITH CYLINDRICAL BOILERS.

Name of ship.	Description of trial.	Prop'r'n full designed power developed.	No. boilers in use on the trial.	Grate area in use, sq. ft.	Heating surface in use, sq. ft.	Steam pressure (by gage.) Boilers, lbs.	Steam pressure (by gage.) Engines, lbs.	Mean effective pressures in the cylinders. H.p., lbs.	I. p., lbs.	L. p. Forward, lbs.	L. p. Aft, lbs.	Mean cut-off in the h. p. cylinder.	Vacuum in condensers, ins.*	Revolutions of main engines pr min.	I. h. p. (total.)	M.E.P. ref'd to l.p. cyldr., lbs.	Abs. press. at release l.p.cyl, lbs.	Total ratio of expansion on trial.	Coal used per hour. Per sq. ft. of grate lbs.	Coal used per hour. Per I.h.p., lbs.
"Diadem"	30 hours' coal consumption	0.201	8	392	10,820	265	202	31.02	10.44	7.15	7.87	0.27	27.1	67.24	3,318	15.8	6.4	15.7	18.4	2.18
	30 hours' coal consumption	.776	30	1,462	40,550	280	245	79.00	28.07	16.40	16.46	.54	26.7	107.67	12,813	38.0	12.0	10.3	13.9	1.59
	8 hrs full p'w'r	1.046	30	1,462	40,550	291	249	88.87	33.56	21.09	21.44	.68	26.7	119.1	17,262	46.5	16.0	8.7	20.8	1.76
	4 hours' trial.	.961	24	1,140	31,720	291	229	84.18	33.76	19.00	19.31	.68	26.7	116.3	15,861	43.7	15.8	8.7	27.1	1.95
	15 hours' trial.	.198	8	392	10,820	275	244	30.81	10.71	7.57	8.02	.27	26.5	64.7	3,266	16.2	6.9	15.7	19.6	2.35[1]
	15 "	.431	16	784	21,640	257	156	53.84	20.00	10.22	10.56	.54	26.1	89.5	7,119	25.5	8.5	10.3	17.6	1.94[1]
	30 hours' trial.	.78	24	1,140	31,720	265	240	79.15	30.56	15.42	16.06	.54	26.0	107.2	12,852	38.4	12.0	10.3	21.2	1.88[1]
Recent representative battleship	30 hours' coal consumption	.518	8	820	25,045	139	136	32.43	19.00	8.68		.555	27.7	82.91	6,216	23.8	8.0	..	13.8	1.82
	8 hrs.' natural draft.	.872	8	820	25.045	150	148	48.24	25.07	13.13		.638	25.6	97.16	10,465	34.3	11.7	..	20.5	2.3
	4 hours' full power.	1.023	8	820	25.045	152	147	54.14	28.04	14.69		.707	26.4	101.8	12,280	38.4	14.0	..	Not taken	...
Recent representative 24 class cruisr	30 hours' coal consumption	.513	8	626	18,700	145	142	38.35	18.55	8.9		.39	26.6	117.85	4,925	24.7	7.9	..	12.6	1.6
	8 hrs.' natural draft.	.855	8	626	18,700	149	149	54.00	28.55	12.3		.63	28.1	136.15	8,208	35.6	11.2	..	28.8	2.2
	4 hours' full power.	1.025	8	626	18,700	151	147	66.55	30.45	13.5		.75 to .69	27.9	144.95	9,840	40.1	14.0	..	Not taken	...

*Inches of mercury.
[1]Coal hand-picked, but very productive of clinker. Fires cleaned practically every eight hours.

and all subsequent trials the necessary auxiliary machinery was at work, and the coal consumption includes the expenditure for this purpose, no deduction having been made on this account and no additions having been made to the indicated horse-power shown by the main engines. The coal used, therefore, includes that for the auxiliary engines connected with the main engines—the evaporating apparatus, steering engine, and a 600-ampere dynamo supplying electric light to the whole ship. The second trial was contract 30 hours at 12,000 I. HP., i. e., about 75% of the maximum specified power, with all boilers in use. The power realized was 12,813, while the coal consumption, taken as defined in the contract, for 24 consecutive hours, was 1.59 lbs. per I. HP., or 13.9 lbs. per sq. ft. of grate per hour. A mean speed of 19.79 knots was realized. The boilers generated steam freely, the stokeholds being open and the fans not in use.

The third contract trial, i. e., at 16,500 I. HP. for eight hours, with all boilers in use, was carried out on Jan. 26, when a mean collective I. HP. of 17,262 was obtained with open stokeholds and the ventilating fans running slowly. The coal consumption was 1.76 lbs. per I. HP., or 20.8 lbs. per sq. ft. of grate per hour. The speed of the vessel was 20.6 knots as the mean of the three runs. The first two runs were made on slack water, and the third against a tide. The mean of the first two runs was 20.72 knots.

In addition to the preceding contract trials the following experimental trials were carried out: In the first place it was desired to test the capability of these modified boilers when being pressed beyond the amount necessary to obtain the specified maximum power. For this purpose a trial of four hours was made with the three after stockholds only, the boilers in which amounted to 78% of the total boiler power of the ship, developing about the specified maximum power. On this trial the horse-power realized was 15,861, the coal consumed per I. HP. per hour being 1.95 lbs., and the coal burned per sq. ft. of grate 27.1 lbs. per hour. The boilers generated steam for this power satisfactorily, but accelerated draught was necessary to the extent of 0.3-in. of air pressure in the stokeholds. With a higher air pressure no doubt the proportion of boilers used would have generated a still higher power, but it was considered undesirable to press them further beyond the contract amount. On this trial the combined heating surface in the generators and economizers was at the rate of about 2 sq. ft. per I. HP.

Similar trials were made with the same boilers, i. e., 78% of the total boiler surface, to test their capacity for maintaining for long periods a higher power than contracted for, and it was endeavored to obtain with this proportion of boiler power the full continuous steaming power, i. e., 75% of maximum power specified to be obtained with the whole of the boilers at work. This was successfully realized, and, with open stokeholds, 12,852 I. HP. was maintained for 30 hours, the coal consumption per I. HP. being 1.88 lbs. per hour, or 21.2 lbs. per sq. ft. of grate. On this trial the coal, although hand-picked, was of an inferior quality as regards quantity of clinker, which necessitated the fires being cleaned much oftener than usual. They were completely cleaned each eight hours.

Another trial was made of 15 hours' duration, under exactly the same circumstances as the first contract trial, with a view of confirming or otherwise the coal consumption then shown; but, unfortunately, the coal in the bunkers on this trial was much inferior, and produced a much larger amount of clinker; 3,266 was obtained, and the coal consumption was 2.35 lbs. per I. HP., as against 2.18 lbs. obtained on the original trial, and the difference

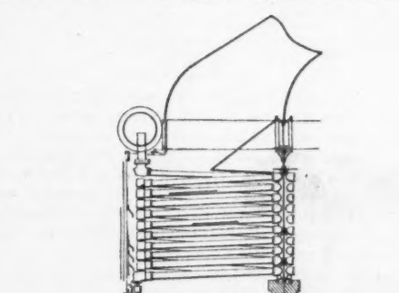


Fig. 2.—Section Through Belleville Boilers of British Cruiser "Powerful."

between these two figures may be regarded as entirely due to the quality of the coal and to the constant cleaning and clinkering necessary.

A further trial was made of 15 hours' duration to compare the powers developed in the engines, using 150 lbs. steam pressure, with that obtainable at 250 lbs. pressure, the cut-off in the cylinders being the same. The trial selected for comparison was the second contract trial, and the links were therefore set at the same position as they were on that trial, when an I. HP. of 12,813 was obtained. The mean power at this reduced pressure was 7,119, the revolutions being 89.5, as against the 107.6 on the original trial. The power was therefore about 60% of that obtained with 250 lbs. pressure. The coal consumption was 1.94 lbs. per I. HP. per hour. As the same inferior quality of coal as regards clinker was used, this consumption is, no doubt, higher than would otherwise have been the case.

On all the trials the pressure of steam in the supply pipes to the auxiliary machinery was restricted by reducing valves to about 150 lbs. per sq. in. On the trials of the "Powerful" and the "Terrible" it was found particularly necessary to regulate the firing, while on the trials of the "Diadem," with the modified type of boiler, such close attention, although beneficial, was found to be not so necessary, and more latitude in thickness and level of fire is permissible.

A comparison of weights per I. HP. in recent designs, similar to that given last year in the case of the "Powerful," is given in Table B.

The "Diadem" and "Powerful" are compared in Table B with nine recent battleships with cylindrical boilers and 155 lb. steam pressure. It will be seen that the percentage of increase per ton weight of boilers and fittings, comparing the full power of the "Diadem" with the natural draught power of the nine battleships, is 58.4%, while in the "Powerful" the corresponding figure is 54.5.

In conclusion it is submitted the trials carried out in the "Diadem," which have been neither few in number nor generally short in duration, have shown that the engines and boilers are economical and efficient for warship service, and the fitting of the economizer to the boilers has been attended with beneficial results.

TABLE B.—Comparison of Machinery of "Powerful," "Diadem" and Recent Battleships.

Ship.	I. HP.	—A— Weight of machinery in engine-rooms.	—A— I.h.p. per ton of A.	—B— Weight of propellers, etc.	—B— I.h.p. per ton of B.	—C— Total weight main engines, propellers, etc., = A + B.	—C— I.h.p. per ton of C.	—D— Weight of boilers and fittings.	—D— I.h.p. per ton of D.	—E— Total weight main machinery and boilers = A + B + D.	—E— I.h.p. per ton of E.
Average of 9 recent battleships	10,000 (N.D.)	445.01	22.47	98.17	101.86	543.18	18.41	719.31	13.92	1,262.49	7.92
	12,000 (F.D.)	...	26.96	...	122.23	...	22.092	...	16.706	...	9.505
"Powerful"	25,000	789.5	31.66	192.72	129.7	982.2	25.45	1,162.05	21.51	2,144.27	11.7
Percentage of inc. over battleships.	Compared with N. D.	...	.....	..	...	...	.....	...	54.52	...	..
	Compared with F. D.	...	17.433	..	6.126	...	15.20	...	28.75	...	..
"Diadem"	16,500	576.45	28.62	111.9	147.45	688.35	23.97	748.4	22.05	1,436.75	11.48
Percentage of inc. over battleships.	Compared with N. D.	...	.....	..	...	...	.....	...	58.405	...	..
	Compared with F. D.	...	6.16	..	20.63	...	8.501	...	31.988	...	20.778

N. D.—Natural draft. F. D.—Forced draft.

A STRONG AND LASTING CEMENT FOR RUBBER says "The Engineer," can be made as follows: Put one part of shellac, broken into small pieces, into ten parts of strong ammonia water; and leave the compound to stand for three or four weeks, or until the mass becomes entirely fluid. When wanted for use in cementing rubber to metal or wood, apply the liquid to the rubber surface and then firmly wire the rubber to the metal or wood. When the ammonia has evaporated the two substances will be found to be firmly joined together.

AN INSTRUMENT FOR SEEING UNDER WATER has been devised by Malachowski, an engineer of Cracow, according to the "Mittheilungen über Gegenstände des Artillerie und Genil-Wesens" (Engineering, April 15.) By its means plant and animal life can be studied under water, and ships' hulls and bridge piers be examined. The instrument is practically a binocular with a long tube. It consists of three parts—the lenses, the diverging tube, made of zinc, and the closed box into which the zinc cone fits. This box is made of sheet-iron, has a diameter of about one foot, and is closed below by a strong glass plate packed between rubber washers. In order to protect the plate from stones the box is provided with iron feet. The field of view under the plate is illuminated by an electric incandescent lamp, which is held by a bent arm. Another lamp can be fixed in a short branch tube starting from the box. This branch, which is hermetically sealed, is needed because the moisture would condense on the inner face of the glass plate if this face were not carefully painted with pure vaseline. To do this, the box must be accessible. Weights are required to overcome the hydrostatic pressure. That pressure might crush the glass plate, and the water, rushing up, damage the lenses and the eye of the observer were it not that such water would find an exit through an opening in the upper part of the tube. Malachowski has experimented with tubes 50 ft. long. The electric wires are carried down inside the tube. When lateral observations are to be made, as will generally be the case on board ship or for operations connected with hydraulic engineering, the inventor employs a different box in which a mirror is placed at an angle of 45°. We do not know, says the account, how far the experience of the inventor extends, but he seems to have overcome the more apparent difficulties.

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The results of an interesting series of tests of wrought-iron cylinders under compression are given in a paper by Prof. W. K. Hatt, of Purdue University, in another column. These tests furnish confirmation of the impossibility of assigning any definite figure as the "ultimate crushing strength per square inch" of wrought-iron, or of any other ductile material, since in short specimens the metal simply bulges and continues without limit to offer an increased resistance to compression as it is shortened in length. The tests are also of value in showing that there is a certain degree of uniformity in the elastic limit under compression of cylinders of the same material, but of different dimensions, and also a uniformity in their limit of plasticity, beyond which the resistance of a specimen, while steadily increasing per unit of original area, remains constant per unit of the gradually increasing area.

We cannot agree with Prof. Hatt's proposition to define the term "crushing strength" as being equivalent to the "limit of plasticity," and the term "compressional strength" as being the elastic limit, when referring to ductile materials. In the common use of the language, both in technical text books and by the public, the terms "crushing" and "compressive," or "compressional," as Prof. Hatt has it, are used synonymously, and the attempt to take any one of these words and restrict it to mean something different from what it has always meant heretofore is bound to fail. It is, and will always be, proper to speak of the crushing strength of a column of wrought-iron, meaning that load which, if exceeded, the column will fail. At the same time it is, in a technical sense, inaccurate to speak of the "ultimate crushing strength per square inch of wrought-iron," for, as Prof. Johnson says in his "Materials of Construction," p. 24,

> there is no such thing as an "ultimate strength" in compression of a plastic body. There is, however, a definite "apparent elastic limit," the same as in tension. Beyond this limit the material simply spreads and increases the area of its cross-section indefinitely under an increasing load.

As Prof. Hatt shows, there is an elastic limit, or yield point, per square inch, in compression, and a plastic limit per square inch, which are practically constant for a given material without regard to the dimensions of the specimen. The terms "elastic limit per square inch in compression" and "plastic limit per square inch in compression," while somewhat cumbrous, are the best terms we have to express the things they signify, while "crushing strength" and "compressive strength" are altogether unsatisfactory terms for the purpose.

We have said that the elastic limit, or yield point, of these specimens of wrought-iron is approximately constant for a given material. In the records of Prof. Hatt's tests, series A, 0.5 sq. in. area, gives yield points varying from 36,290 to 43,234 lbs. per sq. in., and series B, 1 sq. in. area, of the same material, from 30,250 to 42,820 lbs. per sq. in., there being no relation in either series between the length of the specimen and the variation in yield point. For this material the elastic limit in tension was 40,000 lbs. per sq. in. In series C, 0.75 sq. in. area, a different iron, whose yield point in tension is 26,000 lbs. per sq. in., the yield point in compression ranges from 19,320 to 23,450 lbs. per sq. in., and in series D, 0.25 sq. in. area, of the same iron as C, it ranges from 25,620 to 30,050 lbs. per sq. in. The range of variation in each of the two irons is great, but not more than may be accounted for by the great difficulty of fixing compressive test specimens in the testing machine, so that there will be no eccentricity of loading and of making the very minute readings which are necessary to obtain the yield point with accuracy. On the whole we think these tests fairly confirm what Prof. Johnson says concerning the elastic limit:

> The elastic limit in compression for iron and steel is fortunately about the same in pounds per square inch as the elastic limit in tension. It is not customary, therefore, to test such materials in compression, but to assume that they have the same elastic limit in compression which they are found to have in tension.

Heating feed water by live steam is still claimed by some writers to give an economy of fuel. "The Engineer," of London, in its issue of April 8, has a long editorial on the subject, claiming that about ten years ago Mr. John Kirkaldy discovered that by taking live steam out of a boiler and using it to heat the water that was fed into the boiler, an important saving of fuel resulted. "The Engineer" says:

> At first we disbelieved; finally we carried out an experiment on board the steamship "Oriole," which convinced us that Mr. Kirkaldy was quite right and had made virtually a new discovery in thermodynamics. It may be worth while to say here that Mr. Kirkaldy was denounced as a lunatic and that it was pretty generally held that he knew nothing about thermodynamics, or we would not endorse the absurd nonsense that the saving of 10% or so could be effected by using full-pressure steam to raise the temperature of feed-water.

The test on the steamship "Oriole" was reported by "The Engineer" in its issue of July 3, 1891, and it now claims that its endorsement of Mr. Kirkaldy's claims are justified by the fact that his heaters are applied to boilers on sea and land aggregating 4,000,000 HP. We are still skeptical concerning the reported economy of fuel, notwithstanding "The Engineer's" endorsement of it for seven years. We are not disposed to discuss its theories, but we would suggest that the experimental proof of the saving claimed is still insufficient, and that before we can accept its conclusions we should see the report of an unbiased commission of engineers on the test of a boiler which already had a good record for economy before the heater was attached to it.

About a year ago the Institution of Civil Engineers, in London, framed a new set of by-laws, requiring an examination, under stated conditions, for admission to the grade of Associate Member. The practical working of the new system is outlined in the recent presidential address of Sir John Wolfe Barry; and it is interesting in connection with a radical effort to elevate the professional requirements for membership in engineering societies of recognized standing. Since the by-laws were passed requiring examination, 118 entries of candidates have been made, and of these 89 would be classed, if elected, as Associate Members. Of the 89, 60 have been readmitted for examination, or for the submission of certificates from examining bodies recognized by the Council. At the first examination held by the Committee of the Institution only a few candidates presented themselves, and 8 were passed on their previous University certificates. The President attributes the smallness of the number of candidates to the shortness of time available for adequate preparation for the examination, and to the necessity, in the case of many persons, for some reading and study. In the case of the 89 referred to, in 21 cases the submission of a thesis was accepted in place of an examination; and for 8 applicants, both examination and thesis were waived, owing to the record of professional experience and position which they had already attained.

In commenting upon this method of controlling admission to the Institution, or to its secondary grade, the President of the Institution remarked that the rules for examination may need revision; especially, as the departure was a new one, and experience alone can teach what is best. But he was convinced of the wisdom of such a course, and of the advantages which would flow from it, to the profession and to the public. The purpose of the examination was to ensure that a man possessed the qualification of theoretical knowledge before he was classed as an engineer by the Institution. But he warned his hearers that practical knowledge was, at least, as necessary as theory; and while advocating the cultivation of the latter he very strongly felt the immense importance of the former; both are necessary to make the engineer required by modern demands. Sir John referred to the present world-wide competition in engineering matters which Englishmen must face; and said that he believed it essential that engineers, to meet this competition, should have thorough scientific instruction in the fundamental branches on which engineering practice is based, and that they should associate with this theoretical training that practical knowledge which can only be gained in the drafting-room, in the workshop, and on works under construction. He pointed out the fact that the new examinations were not in lieu of the other qualifications, as set out in the by-laws, but supplementary to them. In the transition period, some inconvenience would doubtless be felt among individual candidates for election to the class of Associate Member; but this was also the case when, in 1889, examinations for the Student class were instituted. In the latter case the Council found that many applications required special treatment and some relaxation of the requirements; and the number of applicants also fell off. But, in the case of the Students, the number of applications reached its minimum some few years after examinations were made obligatory, and it has steadily increased since. The same course will probably have to be pursued with the Associate Members, and similar results are expected. In the Student class the system has also developed a commendable esprit de corps, which is distinctly recognizable; and to be a Student of the Institution is now regarded as being a member of a body with certain qualifications of a distinct and recognized standard. Sir John looked forward to the time when the certificate of a Corporate Member of the Institution of Civil Engineers would be recognized throughout the world as the highest and most coveted degree in engineering, as well as a warrant of social standing.

This new departure in the Institution of Civil Engineers is the natural outcome of the older system of making English engineers. Institutions especially devoted to teaching engineering are by no means numerous in England, even at the present day; and until quite recently the apprentice system formed the only door for admission to the profession. The candidate entered the office of the practicing engineer, and was supposed to acquire from his master, and from the opportunities presented by his master's practice, the knowledge sufficient to enable him to enter upon the personal design and control of engineering works. It can be readily seen that the amount of theoretical and practical training thus secured depended very largely upon the character and practice of the master; and at the best, this could but compare very unfavorably with the systematic training and the advantages of scientific laboratories, and association with fellow students furnished by a modern, thoroughly equipped engineering school. But the apprenticeship system is passing away, to some extent, and engineering schools are increasing in number in England; and

it is evidently the wise purpose of the Institution, in its examination requirements, to approve and foster the better and more thorough training which the schools supply. In the United States, excellent engineering schools abound; and it is now generally recognized that a course at one of these schools is an absolute essential to any young man seeking to enter the engineering profession, and hoping for anything more than the most subordinate positions.

As yet our American engineering societies have not deemed it advisable to adopt the obligatory examination of candidates for admission to membership; nor do the educational conditions existing here among the younger applicants make this examination as important as it is in England. We do agree with Sir John Wolfe Barry, however, that the distinct, high and fully recognized standard for admission to an engineering society has a great value. It creates an esprit de corps among its members; and the diploma of such a society is a certificate that the world at large will eventually learn to take at its full value. Until such an organization fully appreciates the fact that everyone connected with it is fully and properly entitled to the name of engineer, and has won that name by passing established tests, it can not altogether respect itself. And until it does so respect itself, and has proper reason to be proud of its standing, it can not expect the world to accord its members that respect and confidence to which their abilities and character should entitle them.

THE BATTLE OF MANILA.

The conflict between the United States and Spanish fleets, which took place in Manila bay, in the Philippine Islands, on May 1, will rank as the most remarkable naval battle in the world's history in the great disparity between the effect of the battle on the forces of the victor and the vanquished. On the Spanish side every vessel was sunk or burned or beached to escape destruction, and 618 of the crews were killed or wounded. Of the United States fleet, not a vessel received an injury of any consequence; not a life was lost, and only eight men were slightly wounded. How is this enormous disparity to be accounted for? The question is one which will receive the serious study of naval experts throughout the world.

It is by no means to be explained by the superiority of the United States vessels. We have summarized the armament of the opposing fleets, in the accompanying table. It will be seen that the attacking fleet numbered six vessels, with a total tonnage of 12,591. The Spanish had eleven vessels, not including a number of torpedo boats, with an aggregate tonnage of over 18,000. The advantage of position was with the Spaniards. They were in their own harbor, and were under the guns of their own land fortifications, which gave more or less aid in the battle. They might have led the enemy a chase in the waters with which they were familiar, and decoyed his vessels upon some of the dangerous shoals that are said to underlie Manila bay. They might have disputed the entrance of the bay with the enemy, and set mines and torpedo boats there to destroy his ships. They did nothing of the sort, but acted purely on the defensive and made no movement until the attacking fleet steamed up in line of battle.

The large superiority of the American ships in speed had no influence upon the results of the battle, so far as we now know, for the opposing fleets faced each other in line of battle and there was no question of either flight or chase. Again the fact that the American vessels were of more recent build than the Spanish can have had but little influence on the result. Either fleet was vulnerable at almost every point to the guns of its opponents, if we except the partial protection of the "Olympia" and the "Baltimore," and while the American vessels very likely had their vital parts better protected by coal bunkers, etc., and were less likely to be set on fire, this cannot be held to have contributed in any considerable measure to the result of the battle.

Comparing now the batteries of the two ships, shown in the accompanying table, it is seen that the American fleet had 10 8-in. guns, 23 6-in. guns, and 20 5-in. guns. The Spanish fleet had 7 6.2-in. guns, 7 5.9-in. guns, 25 4.7-in. guns, and 21 guns with calibers from 2.2 ins. to 3.5 ins.

Now against such vessels as were in action at Manila, the heavier calibers of the United States guns by no means represented an overwhelming advantage. We may represent the case fairly by saying that the United States vessels had 53 effective guns in their main batteries, while the Spaniards had 39 of calibers of 4.7 ins. and upward, beside 21 guns of calibers from 2 to 3½ ins. A projectile from any of the 39 larger guns of the Spanish fleet would have done more or less injury to any of the United States hulls had it hit them. If the armament of both fleets were in equally good condition, and if both were fought with equal ability, any naval expert would have prophesied a victory for the Americans, barring untoward accidents and the part which mines or land artillery might play; but a victory won at a heavy cost in the destruction of life and in the injuries suffered by the vessels of the attacking fleet.

To what, then, can we attribute the amazing absence of injury to the American vessels and their crews? We see no other possible explanation than the failure of the Spaniards to make effective use of their weapons. They fought and died with stubborn bravery, and with no thought of surrender; but from all accounts hardly one of the shots from their 39 guns of large caliber seems to have hit the American fleet. From the accounts of the battle now at hand, Admiral Dewey seems to have carried on the fight at a distance at which the gunners of his fleet were able to plant their shots with remarkable precision, but at which the Spanish gunners were almost absolutely unable to hit the American vessels. It was not a sudden attack. The Spanish fleet had full warning of the enemy's approach and was prepared to meet it. Nor were the Spanish vessels disabled before they had time to make a defence. The American vessels stood off and deliberately poured their fire against their antagonists, and in the long hours that the battle continued it seems incomprehensible that not one Spanish gunner was able to give a telling blow to some of the opposing fleet. The guns of the Spanish vessels were of modern make, Krupp, Armstrong and Hontoria, and we believe nearly or all of them were equipped for rapid firing. Who can say where the fault lay that they were not effectively handled? We commented last week on the necessity of discipline and mechanical skill for the working of modern guns, and on the paralyzing influence of corruption in official life upon the military or naval strength of a nation. The result of the Manila engagement seems to lay emphasis on these principles.

In conclusion, it may be said that the Manila victory has shown that American naval commanders of the present day can worthily sustain the fame which their predecessors won in the early days of the Nation's life; and that notwithstanding the criticisms that certain European naval authorities have bestowed in times past, the United States can not only build and equip modern ships of war, but its naval forces can use them to fight battles and win victories.

The Fleets Engaged in the Battle of Manila.

United States.

Vessel.	Tonnage.	Armament.
Olympia	4,012	(4) 8-in. B. L. R., (10) 5-in. R. F. guns, (14) 6-pdr. R. F., (7) 1-pdr. R. F., (4) Gatlings.
Baltimore	3,019	(4) 8-in. B. L. R., (6) 6-in. B. L. R. ; (4) 6-pdr. R. F., (2) 3-pdr. R. F., (2) 1-pdr. R. F.; (4) 37-mm. Hotchkiss, (2) Colt machine guns.
Raleigh	2,004	(1) 6-in. B. L. R., (10) 5-in. R. F., (8) 6-pdrs., (4) 1-pdrs., (2) Gatlings.
Concord	1,011	(6) 6-in. B. L. R., (2) 6-pdrs.
Boston	2,028	(2) 8-in. B. L. R., (6) 6-in. B. L. R. ; (2) 6-pdrs., (2) 3-pdrs., (2) 1-pdrs., (2) 47-mm. and (2) 37-mm. Hotchkiss, (2) Gatlings.
Petrel	517	(4) 6-in. B. L. R., (2) 3-pdr. R. F., (1) 1-pdr. R. F., (2) 37-mm. Hotchkiss, (2) Gatlings.
Total	12,591	

Spanish.

Vessel.	Tonnage.	Armament.
Reina Maria Cristina	3,520	(6) 6.2-in. Hontoria, (2) 2.7-in., (3) 2.2-in., (2) 1.5-in., (6) 3-pdrs., (2) Maxim mach. guns.
Castilla	3,342	(4) 5.9-in. Krupp, (2) 4.7-in., (2) 3.5-in., (4) 2.9-in., (2) machine guns.
Don Juan de Austria	1,130	(4) 4.7-in. Hontoria, (3) 2.2-in., (2) 1.5-in., (5) machine guns.
Don Antonio de Ulloa	1,130	(4) 4.7-in. " (2) 2.7-in., (5) machine guns.
Velasco	1,152	(3) 5.9-in. Armstong, (2) 2.7-in. Hontoria, (2) machine guns.
Isla de Luzon	1,030	(4) 4.7-in. Hontoria, (2) R. F., (2) machine guns.
Isla de Cuba	1,030	(4) 4.7-in. " (2) R. F., (2) machine guns.
General Lezo	524	(2) 4.7-in. " (1) 3.5-in., (2) small R. F., (1) machine gun.
El Cano	524	(3) 4.7-in. " (2) R. F. (small), (2) machine guns.
Isla de Mindarado	4,195	Merchant vessel armed as auxiliary cruiser.
Marquis de Duero	500	(1) 6.2-in. smooth-bore, (2) 4.7-in. guns, (1) machine gun.
Total	18,077	

THE EFFECT OF TEMPERATURE ON THE SEEPAGE OF WATER FROM IRRIGATION CANALS.

The great lack of authoritative data on the flow of underground waters has doubtless made itself evident to every engineer who has had occasion to study the question. One of the phases of this subject on which more light is needed is brought to our attention by the following letter from a correspondent in San Bernardino, Cal.:

In some litigation here recently to settle the amount of seepage from a ditch, some of the experts testified that the rapidity of the seepage from the ditch depended very much on the temperature of the soil (fine sandy soil) and the temperature of the water, because water is more viscous at low than at high temperature and because the pores of the soil expand and enable it to receive more water when warm than when cold. The conclusion was therefore that percolation through fine sand or sandy soil is more rapid when the water is warm and less viscous than when it is cooler and possesses more viscosity, and that the opening of the pores of the soil by warming it assists percolation. Other experts denied that water possesses the quality of viscosity, and maintained that percolation and seepage under the conditions named were not affected by a rise in the temperature of the soil and water. Will you kindly state what is recognized by authorities as correct in this matter, and if there is any rule for ascertaining the effect of temperature on the percolation of water and its flow through capillary tubes?

We do not believe that the porosity of the soil, and especially of sandy soil, is affected by any variations of temperature to which it would be subjected. The effect of temperature on seepage appears to have received practically no attention in engineering literature. The one direct reference that we have been able to find, and some indirect data from which conclusions can be drawn, indicate that the volume of seepage would rise and fall with increase and decrease of the temperature. Prof. L. G. Carpenter, of Fort Collins, Col., in "Seepage or Return Waters from Irrigation," being Bulletin No. 33 of the Colorado Agricultural Experimental Station, says that "since water is more viscous at low temperature than at high" formulas for the velocity of water through sand, "should evidently include a factor depending upon temperature." He also says:

The effect which temperature might have upon the amount of inflow (the question here being seepage from irrigated lands into streams—Ed.) was not considered of any importance until the unexplained differences caused a consideration to be given to its possible effect. It is known that low temperatures increase the viscosity of water. The effect is especially noticeable in the flow through small tubes, so much so that five times as much water will pass through a capillary tube at 200° as at 32° F. The effect has been noticed on the amount collected by drains, and in varying the discharge in cases like those of the gathering pipes of the Denver Water Co. in the bed of Cherry Creek. A comparison between the soil temperatures of the Colorado Agricultural College and the inflow into these gathering galleries has been made in Bulletin No. 38 of the Utah Experiment Station. * * * With the range of temperature (of the soil—Ed.) at the depth of 6 ft. (20 to 24° F.—Ed.), other conditions remaining the same, one-third more water would flow in August than in March, and at a depth of 3 ft. (range of 32° F.—Ed.), nearly one-half more.

Bovey's "Hydraulics" gives a table for viscosity of water and mercury at different temperatures, that of water ranging from 0.0181 at 0° C. to 0.0032 at 90° C. (32° to 194° F.). The same author gives two formulas for viscosity, (1) by Meyer and (2) by Slotte, as follows, v being viscosity, and t being Centigrade temperature:

$$(1)\ldots\ldots v = \frac{0.0183}{1 + 0.0369\ t}.$$

$$(2)\ldots\ldots v = \frac{0.5212}{26 + t} - 0.00131.$$

As every engineer knows, viscosity is ignored in all ordinary hydraulic calculations, or is consid-

ered simply as an element in surface friction. The smaller the pipes or channels through which water is being conveyed, the more important does the surface friction, and, therefore, the viscosity, become. As Professor Carpenter well says, in the bulletin already mentioned:

The water in passing through sand and gravel must pass through small openings, which form a series of minute, tortuous and long tubes. It is a fact of common observation that the pressure of water is much reduced by attaching a short length of hose, or pipe. In the case of flow through sands, the openings are many times smaller, and the length may be very great, hence no matter how great the fall the effect of the pressure is throttled by the friction.

Quoting again from Bovey's "Hydraulics":

The term fluid friction is applied to the resistance to motion which is developed when a fluid flows over a solid surface, and is due to the viscosity of the fluid. This resistance is necessarily accompanied by loss of energy, caused by the production of eddies along the surface, and similar to the loss which occurs at an abrupt change of section, or at an angle in a pipe or channel.

* * * * * * * *

The experiments of Unwin and others have shown that the surface friction is diminished by about 1% for every rise of 5° F. in the temperature, and it is also known that the viscosity diminishes as the temperature rises, and vice versa.

Possibly the word viscosity is used wrongly above. Certainly it is in the first sentence of the quotation, where the whole cause of surface friction is attributed to viscosity. But the quotation has been made in order to show, in connection with what has preceded, why temperature has an effect on seepage. Seepage is unquestionably accompanied by a vast amount of surface friction, so large that, whereas viscosity may be ignored in the flow of water through large channels, we may readily believe that it exerts a great influence here.

We said at the start that there is practically no literature regarding the effect of temperature on seepage. It is also true that there is but little on seepage in general, or on the flow of subsoil waters. More scientific attention has been given to the flow of water through sand filter beds than to natural underground flows. In the report of the Massachusetts State Board of Health for 1892 there is a paper on "The Physical Properties of Sands," by Mr. Allen Hazen, Assoc. M. Am. Soc. C. E. Mr. Hazen there gives a formula for the vertical flow of water through sand, in which account is taken of the temperature. In "The Filtration of Public Water Supplies," published some two or three years later than the above, the same author discusses the subject more briefly, and presents the formula in a modified form, with explanations of terms, as follows:

The frictional resistance of sand to water when closely packed, with the pores completely filled with water and in the entire absence of clogging, was found (in the Massachusetts experiments—Ed.) to be expressed by the formula:

$$v = c\,d^2\,\frac{h}{l}\left\{\frac{t\ \text{Fahr.} + 10^\circ}{60}\right\},$$

where v is the velocity of the water in meters daily in a solid column of the same area as that of the sand, or approximately in million gallons per acre daily;

c is a constant factor which present experiments indicate to be approximately 1,000;

d is the effective size of sand grain in millimeters;

h is the loss of head;

l is the thickness of sand through which the water passes;

t is the temperature (Fahr.).

The formula can only be used for sands with uniformly coefficients below 5 and effective sizes from 0.1 to 3.0 mm., and with the coarser materials only for moderately low rates.*

Mr. Hazen publishes a table in his book showing the relative quantities of water at different temperatures which passed through experimental filters. Taking as unity the quantity passing at 50° F., 0.70 passed at 32 and 1.35 at 71°; or for every three degrees increase in temperature the quantity of water passing increased by 5%. This, it must be remembered, is for sand in the condition described above.

We have given such information bearing on the inquiry of our correspondent as we could find. Its application to specific cases we must leave to others, adding only a word of caution regarding the probable range in temperatures entering into the problem. Ground water temperatures must of necessity be practically the same as those of the soil through which the water is moving, especially where the water passes for long distances through the soil, as in the case of most underground flows. The waters of a canal or ditch would, of course, have a wider range of temperature. If seepage from such sources found a speedy outlet to the surface, or into some stream, its temperature would not be much altered in the passage; but if the outlet were at some distance, the water might soon become of the same temperature as the soil, although with a constant underground flow the tendency might be towards a mean. The depth of the ground water level would be an important factor, the soil temperature being much more uniform at 6 ft. below the surface than at 3 ft., for instance. For the information of those interested we would say that the reports and bulletins of the several state agricultural experiment stations contain detailed figures of observations of soil temperatures and both mechanical and chemical analyses of soils.*

We trust that this discussion will elicit some information on not only the special point raised by our correspondent, but also on other phases of the flow of underground waters. The subject is rapidly growing in importance, being intimately connected with both the sources of supply and the distribution of water for irrigation, the sources of water supplies for cities, and the filtration of both water and sewage.

*Effective size is "the size of grain such that 10% by weight of the particles are smaller" than this. Uniformity coefficient is "the ratio of the size of grain which has 60% of the sample finer than itself to the size which has 10% finer than itself.—Ed.

*Some of these figures, from widely varying sections of the country, are given in "Sewage Disposal in the United States," in a chapter entitled "On the Temperature of the Air and of Natural Soils and Its Relation to Sewage Purification by Broad Irrigation and Intermittent Filtration."

LETTERS TO THE EDITOR.

A Forerunner of the Septic Tank System of Sewage Treatment.

Sir: Among the many recent applications of science in sanitation perhaps none is attracting more attention just now than the septic tank system (so-called) of sewage disposal which was described in the Engineering News for Jan. 13, 1898. The theory of its operation, in which the sludge is liquefied by bacteriolysis through the life process of liquefying bacteria, principally anaerobic, is pretty well known, but it may be of interest to readers of the Engineering News to know that the practical application of this method of sludge disposal is not a new one. The ordinary cesspool suggests itself at once as an imperfect illustration of a septic tank, although the continuous circulation required for its satisfactory working is lacking; for it is now known that the waste products of bacteria in concentration are detrimental to their development.

But the reader will find, on reference to Engineering News of April 15, 1882, an illustrated description of "An Automatic Vault Cleaner," which is, in essential respects, our septic tank of to-day.

As the article referred to may be inaccessible to many readers, I venture to quote it in full.

Kenneth Allen.

Equitable Building, Baltimore, Md., April 19, 1898.

An Automatic Vault Cleaner.

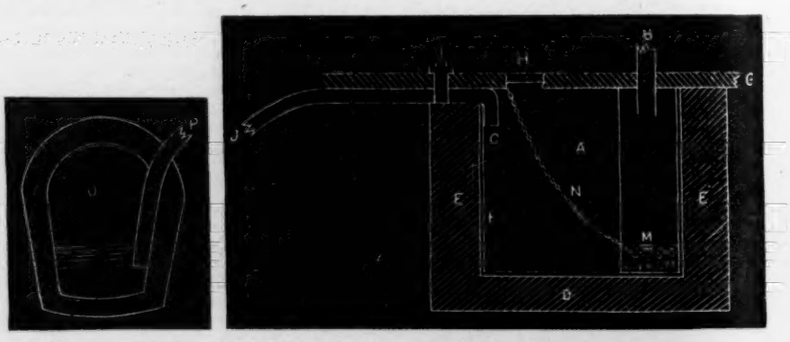
(Translated for Engineering News.)

The principles on which M. Mouras bases the action of this machine is that the animal dejecta contain within themselves all the principles of fermentation or of dissolution necessary and sufficient to liquefy them, and to render them immediately useful in their return to the soil and without appreciable loss.

In the figure, A is the vault, B the soil-pipe from the house, C the syphon discharge pipe, D concrete foundation, E walls, F plastering in cement, G flagstone curbs, H manhole to the vault, I plug for inspection, J drain-pipe to the street sewer, M box of sand to catch any solids which may accidentally enter through the soil-pipe, N chain holding this box and by which it may readily be turned up to the manhole and cleaned out, O street sewer with house-drain, P, trapped by the sewer water.

The vault may be constructed of any material which can be made water and air-tight, of a capacity of 1 cu. m. to suffice for the service of a house of from 20 to 25 persons. The vault being filled with water, the tightness of the construction and the traps cut off all emanations or escape of gas from the interior into the house.

After the fecal matters enter the vault in sufficient quantities, the liquid becomes turbid and of a brown color, but however long continued it may be used, providing that the urine and waste waters enter with it, a fermentation takes place which dissolves all the fecal matters, even the most solid, into particles or filaments so small as scarcely to be discernible, without any deposit adhering to the walls or sides of the pipes. Nothing is more insoluble in itself than fecal matters, as it is covered by an animal grease or mucus, which prevents the water from acting upon it. Experiments were made by means of a vault with glass sides, like an aquarium, perfectly sealed. There being discharged into this aquarium only fecal matters and a very small percentage of water, yet the liquefaction of the excrements was complete, without any decomposition—all remained in suspension. Introduced Aug. 19, the solid dejecta were completely liquefied by Sept. 16, with the exception of the undigested matter, such as seeds and skins of grapes, and some kitchen refuse of vegetables, such as carrots and onion peelings. These floated for a time and then fell to the bottom to await decomposition. Paper disappeared in a like manner. About a liter in bulk of the urine fecal matter and a little water, taken from the aquarium, exhaled but little odor; diluted with 100 times its bulk of water it was limpid and inodorous. Twenty days in succession there was thrown into the aquarium, with the ordinary fecal matter, about 10 liters of a mixture of urine and soapsuds, so as to render the condition as near as may be that of an ordinary cesspool, and the result was that the fecal matters always swam upon the surface, forming a sort of scum never exceeding 5 cm. in thickness, owing apparently to the constant dissolution going on below. On adding 10 liters of water, the matters not digested, such as vegetables or fruit skins, disposed themselves on the top in the order of their specific gravity, and then, after a time, fell to the bottom to await their decomposition, which, operated insensibly, but efficiently, the deposit not being sedimentary but gradually mixing with that above, was discharged with the liquid of the aquarium without any foreign matters appearing in suspension. No pressure from gas is apparent, as was shown by a pipe fixed in the top of the aquarium with a bladder attached, not being distended. On taking off the cover, H, no bad odor was given out, until the air had time to act, when gas began to rise, and, on closing the opening, the bladder became extended. The operation, to be complete, it would seem that the apparaus must be air as well as water-tight. The dissolution of matter seemed more active the greater the quantity of water supplied, which admits therefore of the introduction of house and rain water—but they are not indispensable.



A FORERUNNER OF THE SEPTIC TANK SYSTEM OF SEWAGE TREATMENT.

(This cut is reproduced from Engineering News of April 15, 1882, and shows how line drawings were published in this journal 16 years ago.)

Notes and Queries.

Concerning the reported explosion of a transformer at the works of the Wagner Electric Mfg. Co., St. Louis, Mo., noted in our issue of April 28, the company writes us as follows:

Your informant in this instance has made out a very extravagant bit of news. The facts of the occurrence were not at all as represented. A transformer, in which a defect had been discovered by our testing engineers, was broken down by means of the application of a very heavy pressure, this being the method usually followed in the construction of this kind of apparatus in order to de-

velop faults, if any are suspected, and in every instance to thoroughly test transformers before delivery. The transformer was not undergoing a duty test, and was not immersed in oil. The break-down test employed developed an arc, as desired (the arc indicating the seat of the defect). This arc ignited some of the cotton wrappings, but was promptly extinguished by means of a hand Babcock. Had the transformer been filled with oil there could not possibly have been any damage, as one great virtue of oil in high-tension transformer work is that it prevents ignition of any combustible material used in the transformer and closes up any gap made by an arc as soon as the arc itself is extinguished.

SPAIN'S ARMORED CRUISERS.

Under the above caption, "The Engineer," of London, in its issue of April 29, discusses the principal vessels of the Spanish Navy. Four of these cruisers, the "Vizcaya," "Almirante Oquendo," "Maria Teresa," and "Cristobal Colon," were in the fleet which sailed from the Cape Verde islands when Portugal declared its neutrality, and which are now reported to have gone to Cadiz, instead of seeking a battle on this side of the Atlantic, as was expected.

It will be apparent from "The Engineer's" account that in both armor and armament these Spanish cruisers are formidable foes, much superior in both guns and armor to any of the United States vessels, except its battle-ships, and its armored cruisers, the "New York" and "Brooklyn." We reprint our contemporary's article in full as follows:

The admission of vessels into the category of armored cruisers is governed so much by individual fancy that the term is in many cases misleading. It might well be divided into at least three sub-heads, or else abolished altogether, for at present variations are so great that comparisons between ships designated as "armored cruisers" are well-nigh impossible. There are cruisers, all called "armored," without any other distinction: (1) With armor on both guns and belt; (2) with armor on belt only; (3) With armor on the guns only. To the latter class the Spanish cruiser "Carlos V." belongs, but as a general—and quite unreasonable—rule, ships with armor for the guns only, like our "Powerfuls," are classed as first-class protected cruisers, while a thin 3-in. belt will dignify them with the title of armored cruiser. If we compare the majority of Spanish armored cruisers, the "Vizcaya" and "Infanta Maria Teresa" class, with the Spanish battleship "Pelayo," we see that the sole difference between them is that where the "Pelayo" has a belt all around her the "Vizcayas" have a partial belt for three-quarters of their length and bulkheads. The "Pelayo" has, of course, four big guns against their two, but then she is the bigger ship.

In both cases the guns are identically protected, a narrow barbette, with nothing below save an armored hoist. In each case a thin shield covers the gun breech—a foolish thing probably, since it is just sufficiently thick to burst a shell, and far too thin to keep anything out. Before Yalu the Chinese removed these shields from their battleships, and there was probably wisdom in so doing, though we must bear in mind that the Japanese have since replaced them in the "Chin Yen." Probably, however, the new shields are of tougher armor, but on that no details are available.

We find, therefore, that to all intents and purposes the Spanish "Vizcaya"-class are battleships of the second class, slightly armored, it is true, yet with more armor than the Italian "Lepanto" carries, since that "ironclad" has no belt at all. A vessel which—save that she has a 2-in. armor over the quick-fire guns—is identical to the Italian "Lepanto" in the arrangement of armor is the "Carlos V." She has no belt, but a very thick deck—6 ins.—her big guns in fore and aft barbettes alone are armored. The arrangement of guns is, of course, quite different to the "Lepanto's," but the "idea" in both ships is similar. This idea is that a belt of coal and cellulose, with a thick deck below it, is quite equal to a heavy belt of armor. So far as protecting the engines goes this is true, and it may prove true in other ways. At the best, a belt is only a strip, liable to penetration above and below in a sea way.

The "Cristobal Colon" could, and no doubt will, "lie in the line" if there is a naval action; she is proof against every sort of shell. Except her and the "Pedro d'Aragon," now building, which carry 10-in. guns, all the Spanish armored cruisers carry a couple of 11-in. guns; very good pieces, able to penetrate all the armor on the American battleships' guns.

The American armored cruisers are quite different; they are really armored cruisers. Their belts, instead of being 12-in. steel, as in the "Vizcaya," are of 3-in. steel only; their big guns are only of 8-in. caliber. Now, an 8-in. projectile is quite useless against the belts of the "Vizcayas," or against their barbettes, and in engaging such ships shell fire alone could be depended on to do anything. Of course shell fire is the staple attack, but the "Brooklyn" and "New York" can do nothing against the Spaniards, with their comparatively feeble 8-in. shell, that the Spaniards cannot do against them with a far more powerful gun. It is rank heresy, maybe, but we cannot but hold that there is a tendency to unduly glorify the small quick-fire gun or the medium-sized 8-in. The chances of hitting are, of course, greater with the smaller weapon, both from its extra rapidity and its extra numerical quality; but when the big shot does hit its effect will be, of course, far greater. However, the métier of the Spanish and American armored cruisers is quite different, and it is profitless to compare them. Spain's force is really a number of second-class battleships—known as "armored cruisers"—and these will be pitted against a much smaller number of first-class American battleships. The "many eggs in one basket" is, when all things are considered, the best for battleships. America therefore, apart from other considerations, should win. It is not very safe to prophesy anything, but the probabilities are either a "walk over" for one side, or else an absolutely indecisive but sanguinary result. There is not likely to be a mean between these extremes.

The other principal data with regard to the vessels referred to above are as follows: The "Vizcaya" is an armored cruiser, launched at Bilboa in 1891, carrying two 11-in. guns in two barbettes, and ten 5.5-in. guns, besides smaller weapons. Her displacement is 7,000 tons, her length 340 ft.; breadth, 65 ft., and maximum draught 21 ft. 6 ins. She is propelled by twin screws, her engines developing 13,000 HP. Her normal coal supply is large, namely, 1,200 tons, sufficient to take her nearly 10,000 miles at 10 knots. Her maximum speed is 21 knots. With the exception of the "Pelayo" she and the vessels of the same class are the most heavily armored in the Spanish navy. They have belt armor 12 ins. thick extending from bow to stern, but tapering off at the extremities; their big guns are protected by 10½ ins. of armor, and the deck plating is 3 ins. thick. The "Infanta Maria Teresa," also built at the same time and in the same yard, develops rather more power, but is armed and protected in the same way, and is of the same dimensions. Both ships have six torpedo tubes. The "Almirante Oquendo," "Cataluna," "Cardenal Cisneros" and "Princessa de Asturias" are all very nearly the same in dimensions, and all carry the same guns and armor, so that these six ships form a valuable squadron, and, as the slowest of them can steam 20 knots, they ought, if combined, be able to give very good account of themselves.

The "Cristobal Colon," originally "Giuseppe Garibaldi II.," is of rather less displacement—6,840 tons—and indicates 14,000 HP., but makes only the same speed as the "Vizcaya" class. Her main armament consists of two 10-in. guns and ten 6-in., and six 4.7-in. and four torpedo tubes, so that she is powerful in this respect. She is protected by a 6-in. belt of Harveyed steel, and her guns are similarly provided. Her deck plating is 1½ ins. thick. Her normal coal supply is 1,000 tons. She was launched at Sestri Ponente in 1896.

THE SECOND NEW YORK ELECTRICAL EXHIBITION.

The large amphitheater of the Madison Square Garden, of New York city, the scene of Horse Shows and many other metropolitan events, now resembles a section of the electricity building of the World's Fair. The monotonous hum of electric motors and fans mingles with the splash of the fountain, the weird voice of the phonograph and the hum of the visiting crowd. Overhead festoons of colored bunting partially conceal the iron-work of the great roof and afford an effective background for the lights which are everywhere present.

The central portion of the building is given up to machine exhibits, and, excepting engines and boilers, all apparatus requiring solid foundations is placed here. Some of these exhibits include a considerable amount of large and heavy machinery. One exhibit includes a large railway generator, another several large elevators, another a full-sized street car and a section of conduit electric railway, and still another an electric launch.

Almost in the center of the great floor is an electric fountain, around which the curious throng to see miniature wooden battleships blown to pieces in a realistic manner by torpedoes exploded by wireless telegraphy. Grouped about this fountain in roomy and artistic pavilions are the exhibits of several of the large electric manufacturing companies; their names blazoned in most cases in letters of fire (if one may speak of electric lights in such terms), and their many articles of manufacture displayed to their best advantage, fresh from the factory, bright with new paint, and sparkling with polished brass and nickel plate.

The approach of summer is heralded by fan concerns, whose exhibits in most cases consist of a quantity of fans of all shapes, kinds and colors, but all bran new, humming away most energetically. Opposites seem here to mingle, and near by will be found exhibits of heaters for car and domestic use.

Several styles of electric vehicles come in for their share of attention, but it must be admitted that the looks cast at one of them, a three-wheel monstrosity, differ markedly from those turned towards the latest type of 4-wheel phaeton, manufactured by another concern, which seems to possess only one disadvantage, a good-sized cost price. Electric cabs similar to those in use in and about New York, and a delivery wagon for city service are also to be seen.

Street car trucks and wheels and the like prove of little interest to the general visitor, and hence are passed by in favor of the more showy exhibits, of which there are a sufficient number to afford entertainment for those absolutely devoid of electrical knowledge. These are ranged around the edge of the floor close up to where the boxes begin. They are distributed in such manner as to insure at least a casual inspection by all. In this they remind one of some of the new American magazines, with advertisements sandwiched between the reading matter pages. Here is an exhibit of electrical instruments, next comes a series of experiments conducted by a correspondence school. Here is a cooking exhibit, distributing electrically-cooked cake, and next to it a motor-driven pump. A score of phonographs with long trumpets, now and then permitted to talk or sing, are of interest, while just next a remarkably fine collection of machine tools, used in the manufacture of the more showy instruments, is passed rapidly by.

Over the row of boxes, and extending nearly around the entire amphitheater, a platform has been erected overlooking the entire arena. This is backed by other booths devoted to the smaller apparatus. At the end towards Madison avenue, aptly called newspaper row, side by side in appropriately labeled booths, sit the representatives of nine electrical papers gathered from the East, West, North and South, while at one end of the row, as a sort of chaperone, is found the New York Electrical Society, under whose auspices the exhibition is being conducted. The city telephone company joined hands with two enterprising theaters and has connected a number of telephone receivers with the theater stage, thus affording an opportunity to hear without seeing, an innovation which, however commendable from a moral point of view, leaves the average New York theater hardly a leg to stand on.

In a small room adjoining the exhibition hall are a series of eight wax tableaus illustrating some of the successive stages of electrical development. Further on visitors pass through an aisle partitioned off into boxes. In each box is placed some miniature electrical apparatus operated by a button or key, which the visitor is directed to press and "see the wheels go round." Emerging from this "five minute course in electrical engineering," the visitor passes into a room fitted with pews and an organ representing a chapel. Overhead on the ribs of the arches are placed Vacuum Tubes, which diffuse light throughout the room of practically the same character as daylight.

In the corridors beneath the main floor are located the boilers, engines and generators producing the current used in operating the various exhibits on the floor above. The Generating Section, as this portion of the exhibition is termed, includes 530 HP. of water-tube boilers, and about 300 HP. in steam engines of different makes, most of which are directly connected to generators. Gas engines running singly or connected to generators are also in operation. The many auxiliary devices usual in steam engineering practice, such as separators, lubricators, valves, pipe coverings, engine stops and the like are appropriately located here.

Reviewing briefly, the exhibition as a whole is very creditable, and those having the matter in charge may feel that their efforts to make an interesting exhibition have been successful. The absence of some of the larger manufacturing firms is noticeable, but has been balanced, from the popular standpoint, by the introduction of a

number of novelties doubtless more entertaining to the layman than exhibits of complicated machines.

THE BEHAVIOR OF WROUGHT IRON CYLINDERS UNDER COMPRESSION.

By W. Kendrick Hatt, A. B., C. E.*

The writer here presents the results of a series of compressional tests, made in the Engineering Laboratory of Purdue University during the winter of 1897, by L. C. Fletemeyer, Van W. Alling and himself. The object of the experiments was to determine the influence of the shape of the specimen on its ultimate strength in compression, the ratio of length to diameter at which bending begins, the limit of plasticity, and the ratio of compression at that limit; and to obtain information which might aid in the definition of a standard test piece for compression tests of ductile metal.**

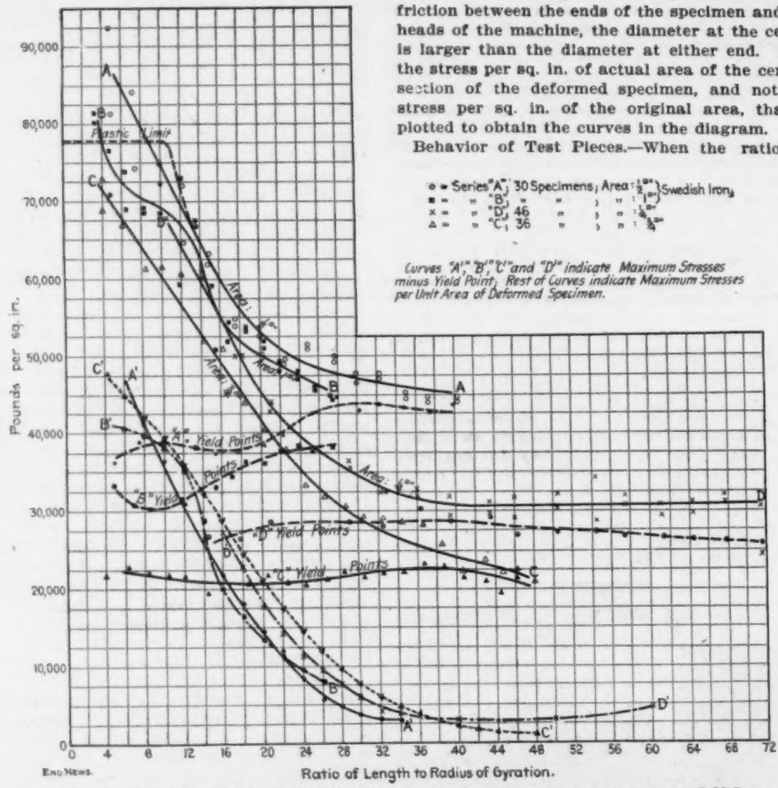

Pounds per sq. in.
Ratio of Length to Radius of Gyration.
Eng. News.
Plastic Limit
Yield Points
Area
Curves "A", "B", "C" and "D" indicate Maximum Strasses minus Yield Point, Rest of Curves indicate Maximum Stresses per Unit Area of Deformed Specimen.

DIAGRAM SHOWING RESULTS OF COMPRESSIVE TESTS ON WROUGHT IRON CYLINDERS.
Tests Made at Purdue University, Lafayette, Ind., by Prof. W. Kendrick Hatt.

Curves showing relation of $\frac{\text{Length}}{\text{Rad. of Gyr.}}$ to maximum load. Specimens are square-ended.

In "C" each point is an average of two experiments.
In Series "A" Plastic Limit is about 77,000 lbs. per sq. in. with a compression of one-fourth.

The tests covered four series of wrought-iron specimens, 142 in all, of areas ¼, ½, ¾, 1 sq. in., respectively, and ranging in length from 1 in. to 12 ins. The specimens of each series were cut from a single rod, and then turned down to a uniform diameter; the ends being carefully squared. Two specimens of each length and diameter were used.

Series A and B included soft Swedish iron of uniform quality, which gave in tension an ultimate strength of 52,000 lbs. per sq. in., an elastic limit (as determined by an extensometer) of 40,000 lbs. per sq. in., and a modulus of elasticity of 29,480,000. Series C and D had an ultimate strength of 53,425 lbs. per sq. in., and a yield point (as determined by the "drop of the beam"), of 26,110 lbs. per sq. in.* Pieces of tool steel were interposed between ends of test piece and heads of machine for Series C and D.

Compression Tests.—The specimens were tested in compression in the 100,000-lb. Olsen universal machine at a speed of 0.025-in. per minute, or else in the 300,000-lb. Riehle machine, at speed of 0.080 in. per minute. The yield point was indicated by the sudden drop in the scale beam. Deflections were read at yield point and at maximum load by means of calipers set between the compression heads of the machine. Diameters of specimens were taken with a micrometer at yield point and at maximum load; and, in order to determine the limit of plasticity of the shorter specimens, lengths and diameters were measured at every 10,000 lbs. increase of load above the yield point. The diameter was read at the center of the length of the test piece. Partly because of the friction between the ends of the specimen and the heads of the machine, the diameter at the center is larger than the diameter at either end. It is the stress per sq. in. of actual area of the central section of the deformed specimen, and not the stress per sq. in. of the original area, that is plotted to obtain the curves in the diagram.

Behavior of Test Pieces.—When the ratio of length to radius of gyration exceeds 30 (that is, when the ratio of length to diameter exceeds 7½—Ed.), the specimen fails by bending under the maximum load, a load but little in excess of the yield point. When this ratio of $l \div r$ decreases from 30 to 10, the specimens fail under an increasing maximum load, both bending and bulging being noticeable. Finally below $l \div r = 10$, failure is mainly due to bulging, accompanied with the formation of longitudinal cracks, at a stress equal to the "limit of plasticity," which limit is 76,000 lbs. per sq. in. for Series A and B, and about 64,000 lbs. per sq. in. for Series C and D. The ratio of compression at the plastic limit is about ¼. The material flows under any additional load, the stress per sq. in. of cross-section of deformed specimen remaining nearly constant. The compression of the specimen follows the law of compression of an elastic fluid. The work done in compressing a cubic inch of the material of Series A and B from the elastic to the plastic limit is 11,480 inch-lbs.,* a quantity about 574 times the elastic resilience. However, as Prof. Cotterill notes, the actual work done may exceed this amount on account of the hardening of the specimen while undergoing deformation.

Series A, then, was elastic to about 40,000 lbs. per sq. in., partially plastic from 40,000 to 77,786 lbs. per sq. in., and plastic at 77,786, with a compression of ¼. Series B was elastic to 35,000 lbs. per sq. in., and partially plastic up to a limit of plasticity of 75,725 lbs. per sq. in., with a compression of 0.27.

The compression of specimens in Series C and D was not carried far enough to satisfactorily determine the plastic limit. This limit was in excess of 60,000 lbs. per sq. in., and the corresponding ratio of compression was larger than in case of Series A and B.

By limit of plasticity is meant that point at which the stress per square inch of actual area of cross section ceases to increase with increase of load. The cohesion of the material seems to be overcome. This point corresponds the point at which a tension test piece necks in.

With reference to the accompanying curves it may be noted that the upper part of curve A, where $l \div r$ is less than 8 (length less than twice the diameter—Ed.) fits the highest individual measurements of stress on these short specimens. But if the curve is drawn to fit the general run of higher values measured during plastic deformation its course will be horizontal to intersect the vertical axis at the limit of plasticity.

For a given value of the ratio $l \div r$, the difference between the elastic limit and maximum stress will be seen to be seen nearly constant for specimens of different grades of iron, and of different diameter.

A specimen whose length exceeds ten diameters will give a satisfactory determination of the yield point. The "crushing strength," which we should fix as the same point as the limit of plasticity for ductile metals, may be determined from a specimen of length less than two diameters. The term "compressional strength" should refer to the elastic limit.

It would seem desirable to introduce some uniformity in the definition of the term "crushing strength" in the case of ductile metals.

The writer does not attempt to discuss the question as to the commercial value of compressional tests on ductile materials. It may be admitted that the ordinary tension test gives a satisfactory index to the quality of the material.

(The accompanying tables are abridged from those given in Prof. Hatt's original records. In nearly all cases two specimens of each length were tested, and the figures given are the averages of the two results.—Ed. Eng. News.)

Compressive Strength of Wrought-Iron Cylinders.

Series A. (0.798-in. diameter = 0.5-sq. in. area.)

Length, ins.	Ratio, length to diam.	Yield point, lbs. per sq. in.	Maximum stress per sq.in. original area,lbs.	Deflection at max. stress, ins.	Final diameter, ins.	Stress per sq. in. of final area.
8	10.01	45,660	46,170	.....	0.815	44,287
7½	9.39	42,550	46,430	0.135	0.816	44,300
7	8.77	43,234	46,420	0.120	0.814	44,675
6½	8.12	43,704	49,800	0.112	0.820	47,175
6	7.51	42,774	50,350	0.117	0.825	47,125
5½	6.89	44,860	53,440	0.130	0.830	49,400
5	6.27	42,460	55,960	0.140	0.837	50,950
4½	5.64	39,570	55,535	0.150	0.850	49 0.5
4	5.02	38,380	60,400	0.200	0.866	51,300
3½	4.39	37,710	68,025	0.542	0.894	54,275
3	3.77	37,314	80,670	0.668	0.907	62,475
2½	3.13	38,830	145,900	1.205	1.155	68,300
2	2.51	38,000	169,000	0.98	1.18	77,650
1½	1.88	38,900	160,000	0.73	1.12	79,250
1	1.26	36,290	160,000	0.44	1.085	86,800

Series B. (Diameter 1.128 ins. = 1 sq. in. area.)

8	7.09	37,960	47,845	0.43	1.165	44,775
7½	6.67	37,885	49,265	0.44	1.166	46,075
7	6.21	38,375	51,412	0.49	1.172	47,700
6½	5.77	37,742	53,287	0.52	1.180	48,575
6	5.32	36,410	57,235	0.58	1.188	51,575
5½	4.88	36,670	62,735	0.87	1.223	53,475
5	4.43	34,633	67,330	1.05	1.269	53,200
4½	3.99	32,982	77,750	....	1.379	54,825
4	3.55	38,522	82,237	0.90	1.245	67,300
3½	3.10	31,062	80,150	0.90	1.282	66,125
3	2.67	38,805	84,290	0.59	1.365	70,350
2½	2.22	30,250	90,000	0.54	1.290	68,800
2	1.77	31,075	100,000	0.54	1.335	71,875
1½	1.33	33,577	120,000	0.52	1.440	73,825
1	0.89	42,820	120,000	0.29	1.375	80,750

*Assuming that plasticity begins just above elastic limit.

*Associate Professor of Applied Mechanics, Purdue University, Lafayette, Ind.

**For a complete discussion of the available data, and the conditions of such tests, see Report of French Commission on the Standardization of Tests of Materials, Vol. III., page 103; for a discussion of the definition of the measurement of plasticity see Vol. III., page 296.

*The 4-in. specimen in Series B most nearly resembles the 1.00 × 3.93-in. cylindrical specimen recommended by the French Commission for determination of Elastic Limit, and the 1-in. specimen in Series A is slightly longer than the 0.74 × 0.69-in. cylindrical specimen recommended for determination of crushing strength.

Series C. (0.903-in. diameter = 0.75-sq. in. area.)

Length, ins.	Ratio, length to diam.	Yield point, lbs. per sq. in.	Maximum stress per sq. in. original area, lbs.	Deflection at max. stress, ins.	Final diameter, ins.	Stress per sq. in. of final area.
12	12.19	20,305	21,950	0.16	0.996	21,062
11½	11.73	21,915	23,300	0.20	1.000	22,250
11	11.20	19,320	23,450	0.22	0.995	22,575
10½	10.66	20,730	24,900	0.27	1.004	25,000
10	10.20	21,600	22,200	....	....	22,000
9½	9.64	22,670	30,800	0.27	1.005	25,715
9	9.16	23,450	29,600	0.27	1.001	28,150
8½	8.76	22,360	30,400	0.26	1.012	28,600
8	8.08	22,440	30,750	0.29	1.007	28,880
7½	7.65	21 570	31,200	0.24	1.008	29,225
7	7.20	22,470	32,400	0.34	1.013	30,300
6½	6.63	21,300	35,100	0.37	1.020	32,450
6	6.22	20,030	36,450	0.40	1.023	33,240
5½	5.61	20,620	42,750	0.56	1.044	37,800
5	5.20	22,200	49,500	0.70	1.08	40,660
4½	4.63	20,800	57,700	1.05	1.12	44,035
4	4.19	.....	81,800	1.45	1.12	61,725
3½	3.65	19,600	88,000	1.30	1.20	58,400
3	3.21	21,500	92,200	1.00	1.19	62,200
2½	2.63	21,760	118,000	1.16	1.36	61,435
2	2.20	22,200	122,000	0.81	1.34	61,310
1½	1.62	22,700	152,000	0.77	1.47	67,000
1	1.21	21,720	148,700	0.55	1.41	70,700

Series D. (0.564-in. diameter = 0.25-sq. in. area.)

10	19.38	25,620	28,300	0.21	0.581	27,375
9½	16.93	26,200	31,600	0.13	0.569	31,350
9	15.78	26,210	30,500	0.10	0.565	30,400
8½	15.19	26,700	30,850	0.12	0.573	30,050
8	14.42	27,250	34,200	0.13	0.572	31,475
7½	13.48	27,800	32,200	0.13	0.570	31,450
7	12.58	27,670	32,200	0.12	0.568	31,725
6½	11.70	26,800	31,500	0.12	0.569	30,600
6	10.70	30,050	32,400	0.17	0.577	30,450
5½	9.80	28,800	33,200	0.27	0.585	30,685
5	9.00	30,300	35,000	0.30	0.585	32,275
4½	7.93	27,700	35,400	0.22	0.591	32,400
4	7.13	32,100	38,750	0.34	0.586	36,000
3	5.32	28,200	49,550	0.34	0.608	43,400
2½	4.40	26,250	66,250	0.73	0.652	50,125
2	3.35	26,900	93,500	0.76	0.663	60,550
1½	2.64	.....	161,800	0.93	0.89	62,500

Methods of Failure.

Series A—Lengths 4½ to 8 ins., inclusive, failed by bending; lengths, 3, 3½ and 4 ins., by crushing and bulging; lengths, 2½ ins., mostly by bulging; lengths, 1, 1½, and 2 ins., by bulging.

Series B—Lengths 6½ to 8 ins., inclusive, by bending; 5½ and 6 ins., by bending with slight bulging; 4, 4½ and 5 ins., by bending and bulging; 1 to 3½ ins., inclusive, by bulging.

Series C—Lengths 5½ to 12 ins., by bending; 3½ to 5½ ins., by bending and bulging; 3 ins., mostly bulging; 1 to 2½ ins., bulging.

Series D—Lengths 3½ to 10 ins., by bending; 2½ and 3½ ins., crushing and bulging; 1½ and 2 ins., bulging.

A BOILER EXPLOSION IN PATERSON, N. J.

The accompanying photographic view illustrates the effect of a boiler explosion which took place at 4.15 a. m., on May 6, at the works of the Passaic Rolling Mill Co., Paterson, N. J. One fireman was killed, and two others were injured. Two boilers out of a battery of ten exploded. The exploded boilers were torn to pieces and distributed over the neighborhood, the section of the boiler house in which they were enclosed was completely torn away, and the adjoining boilers dislodged from their places. The boilers were of the ordinary horizontal tubular type, with large steam drums. The cause of the explosion is as yet unknown. It is said that a recording steam gage in the works shows that at the time of the explosion the boilers were carrying only 60 lbs. pressure.

WRECKAGE CAUSED BY A BOILER EXPLOSION IN PATERSON, N. J., MAY 6, 1898.

THE LEVEES OF THE RED RIVER IN LOUISIANA.

In a paper lately presented to the Louisiana Engineering Society, Mr. F. M. Kerr reviews in detail the past conditions in the valley of the Red River, in Louisiana, the influences at work, and the progress made in protecting the arable land from overflow. While of great local interest, the length of the paper compels us to be satisfied with abstracting from it the matters of more general interest, as follows:

The Red River of the South has its source at the eastern rim of the Llano Estacado, of Texas. From its source to where it is joined by the Wachita River, the stream is shallow and flows swiftly over a sandy bed; below this juncture the river meanders through alluvial bottoms until it reaches the Louisiana state line, 1,200 miles from its source, and 395 miles from the point at which it enters the Mississippi. The basin of the Red River covers 90,000 square miles, and is the smallest of all the basins influencing conditions in the Mississippi Valley. But the rainfall, at times, is the highest of record anywhere in the valley.

The Red River in Louisana is divided by Mr. Kerr into two divisions, the upper and the lower half, with the division line at Montgomery. The upper half is very tortuous, with an extremely variable section, and steep and irregular slope; changing with flood conditions from a placid stream to a torrent. Its banks are friable and easily worn away, and cut-offs have occurred for ages past. The lower half is generally less tortuous, has a larger section and is generally more stable. But what it gains over the upper half in these respects is largely lost in wasted energy in low water periods. The only tributary, of any moment, in Louisiana, is the Black River, about 33 miles above its mouth. But a chain of lakes carries the drainage of a large area, between Jefferson, Texas, and Shreveport, La., into the Red River, through Twelve Mile and Cross Bayous. Other bayous take quite a volume of the overflow; and sometimes send the water back to swell the lower end of the river; but these are not the sources of high stages of water, and are chiefly of local effect. The name, Red River, is derived from its generally red color, produced by the red silt carried by the water.

The Red River of the remote past was evidently a very erratic stream, and its channel has, in time, shifted pretty much all over the northwest part of Louisiana. This change, of course, was mainly brought about by the vast amount of drift of all kinds transported, and the consequent jams and dams which forced the river into new channels. The remnant of this condition was, until 1888, to be seen in the Great Raft, which extended from a point about 50 miles above Shreveport down to Grand Ecore, covering a length of about 200 miles; it, at one time, probably extended lower still. This raft was not one continuous jam; but compact masses of timber extended for many miles in length, with intervals of clear water between. In addition to the visible raft in the bed of the main stream, the caving of the banks and the lowering of the low-water level shows that a large part of the alluvial soil of the valley rests upon vast beds of timber brought down in the remote past.

Besides the Great Raft, there is another obstruction in the Red River—the Falls, at Alexandria, 117 miles above the mouth. These falls are about one-half mile in length, with a drop of about 3 ft., and they are formed by the river here crossing a formation of extremely soft and friable sandstone. While various plans have been proposed for the removal of this obstruction, the only work done in that direction has consisted of cutting away portions of the rock bed so as to make a narrow channel through the falls. The control of the Red River is now being slowly effected by the combined efforts of the U. S. Government, of the state, and of individuals. The government has chiefly occupied itself in removing rafts, snags, wrecks, etc., and lately, to some extent, in assisting the local authorities in building levees. But the partial success of the tentative local levee work has now resulted in the organization of levee districts, with boards of local commissioners empowered to raise revenue, devise plans and to build and maintain comprehensive levee systems, for the east and west banks of the Red River, from the state line to the lower limits of the parishes of Caddo and Bosier; and on the west bank, from Alexandria to the Avoyelles Prairies.

At the present time an embankment, averaging generally 3 ft. above the highest flood record, and with a crown width of 6 ft., and a base width equal to six times the height plus the width of the crown, has been constructed in the Caddo Levee District, from Blanton's Bluff, Ark., to the lower side of Sale and Murphy Canal, a length of about 3 miles down the river. In the same district another levee, 12½ miles long, extends from Bayou Pierre to Tone's Bayou; in addition to these other levees extend up both of these bayous. The aggregate length of levees in this district is 74 miles, leaving gaps equal to 35 miles. In the Bossier Levee District there are about 55 miles of levee; leaving only 12 miles to be built. In the Red River—Atchafalaya—Bayou Boeuf Levee District, the levee line is 37.5 miles long. But with a river so crooked and uncertain in its banks, it will be a long time before all parts of the river have been so developed in section as to properly perform its work; and the only chance of safety for the levee builders to-day, lies in locating the levee line 500 to 1,000 ft. from the present river, to escape caving banks and destruction.

The bottom of the river, in the raft region above Shreveport, has already gone down as much as 15 ft., and the low-water line has followed it to a certain extent. A similar process has been going on below, especially in the stretch called Little River. The high-water line does not follow this improvement; as the development of the valley, cutting of timber and drainage of land has resulted in the more rapid run-off of the rainfall. The general result is, that while the total annual flow remains about the same, the amount discharged per second, in time of flood, is far greater than formerly. A high water of 35 ft., on the Shreveport gage, now means a volume of discharge that could not have been carried by the river in 1849, 1866 or 1874, which were noted high water years. But "high water" is not of annual occurrence on the Red River; and intervals of four or five years elapse without floods of any moment. While the period of high water rarely lasts more than a fortnight, as many as four serious freshets may occur in one year. The reason for the long intervals without flood lies in the great difference in the precipitation in the upper and lower parts of the basins. The rainfall in the lower portion is usually largely in excess of that above; and it is only when both districts are visited by heavy rain storms at the same time that trouble follows.

In regard to the methods of levee building in this section, the writer says that they differ little, if any, from those of other parts of Louisiana. He divides the levee specifications, however, into the

things which are obligatory, those which are required, unless otherwise directed, and those things which must be done only when directed. Under the first category come the following: The removal of all trees, stumps, logs, weeds, trash and perishable material over the entire surface to be covered by the levee; plowing, or spading up this area; grubbing up of all roots over the base area and 3 ft. on each side; the excavation of all buried logs, brick walls, etc.; the cleaning and filling of all cross ditches, for 20 ft. from the base, on the land side, to the edge of the berm, on the river side; the slashing of all trees within 100 ft. of the base of the levee, in woodlands; leaving traverses, as prescribed, across borrow-pits, with connecting ditches, and planting the entire surface of the completed levee with living roots of Bermuda grass, not more than one foot apart.

The things that must be observed, unless otherwise ordered, are as follows: Cutting to the level of the ground all trees and stumps within 25 ft. of the land side of the base; using earth only in building the levee; obtaining all this earth from the river side of the levee, leaving ground undisturbed on the land-side; shaping borrow-pits, and leaving all existing levees and parts of levees undisturbed. The third division, or things which are only done when directed, include the following: Cutting muck ditches, which are really search ditches, extending some feet below the center line of the levee; finishing the clearing, grubbing, etc., and cutting and refilling muck ditches over certain areas before the levee is commenced; cutting down trees in open land, within 100 ft. of base; placing earth in layers of prescribed thickness over full width of levee; cutting openings through old levees, as directed, and digging drainage ditches on land side, as directed. As to shrinkage, the Red River levee contracts uniformly require that all embankments be built to a gross height one-fifth higher than the net fill established. As the soil here is generally sandy, it is almost entirely handled by scrapers and mules; and a large part of the levee-line really stands higher than the official grade height.

Once properly built, these Red River levees are less subject to accident from internal causes than those in other parts of the state. The crayfish does not exist along its banks, and the musk-rat is also absent. The kingfisher sometimes bores horizontal holes into the bank, which might be a source of danger in high water; and the ordinary mole is present, but simply skims along under the surface. Mr. Kerr, however, refers to a species of mole, locally called a "salamander," which is to be found on the lower Red River and Atchafalaya. As described, this somewhat extraordinary animal—

is about the size of an ordinary rat, the head closely resembling the rat, with keen round eyes. The foreshoulders and forelegs are much more developed than the hind members, and they are provided with highly developed hands and long, sharp and strong claws. It uses these forelegs for digging, and the animal has bags or pockets of skin just back of its ears. It digs rapidly, fills the pockets with the loose earth, "turns a somersault," say some, in the tunnel, carries its load to the surface and dumps it at the mouth of the opening.

The small mound thus made is one means of detecting the animal. Mr. Kerr also calls attention to the mischief done to levees by the American "razor-back" variety of hog; though sweeping laws are now enforced against him. Another law forbids traveling on the tops of levees and crossing them with vehicles. Breaking this latter law often affects the integrity of the levees.

FLUSHING PIPE SEWERS.

The necessity of automatic flush tanks in the separate system of sewerage was for many years generally accepted without question by sanitary engineers. In 1895 a paper on "The Separate Sewer System Without Automatic Flush Tanks,"* by Mr. F. S. Odell, M. Am. Soc. C. E., was read at the annual convention of the American Society of Civil Engineers. Mr. Odell told how at Mt. Vernon, N. Y., they were getting on admirably, not only without flush tanks, but with hand flushing by means of fire hose at intervals of only six months. The discussion brought out by the paper, though ranged on both sides of the question, showed a surprising lack of accurate information from which to draw sound conclusions, and indicated that some felt flush tanks to be of but little use, while others hardly knew what to think of them.

In our issue of May 6, 1897, there appeared an article by Mr. Andrew Rosewater, M. Am. Soc. C. E., of Omaha, Neb., on "Systems of Sewer Flushing and Suggestions on Flush Tank Design and Construction," in which the cost of the two systems of flushing was compared by means of estimates, and a number of other phases of the subject were discussed.

At the meeting of the American Society of Civil Engineers, on May 4, 1898, a paper was read by Mr. H. N. Ogden, Jun. Am. Soc. C. E., of Ithaca, N. Y., on "Flushing in Pipe Sewers." Mr. Ogden began his paper by referring to the common use of flush tanks and the great lack of information regarding the relation between the size of the sewer pipe, the amount of flushing water, and the grade of the sewer. He next pointed out that the cost of flushing is quite a large percentage of the total cost of a separate system of sewerage. The city of Ithaca, N. Y., for instance, has 131 flush tanks on 25.3 miles of sewers, or one for every 1,020 ft., these devices having been placed at the head of every lateral, even on 12% grades. Estimating the cost of the flush tanks at $50 each, their total cost would be $6,550, or about 8% of the cost of the whole sewerage system. Assuming that the tanks require but 150 gallons of flushing water each per day, the expense for water, at 20 cts. per 1,000 gallons, the meter rate in Ithaca, would be $3.93 per tank, or $1,434 per year. To this $600 a year is added for the wages of a mechanic engaged in readjusting the tanks. The two items amount to $2,034, which, capitalized at 6%, gives $33,908. Add to this the first cost of the flush tanks, and there results an equivalent of $40,050 for flush tanks, against $81,000 for the rest of the system.

Mr. Ogden presented a table designed,

to show the requirements in grade to maintain a velocity of 2½ ft. per sec. in a 6-in. lateral, assuming a constant contributing population of 7.6 persons per 100 ft. of sewer, with a daily flow of 60 gallons per capita, with the assumption of one-half flowing off in six hours.

In the spring of 1897, Mr. Ogden, assisted by Mr. I. W. McConnell, then a student at Cornell University, made some flushing experiments on four or five lines of sewers in Ithaca. The sewers were 8 ins. in diameter, and were chosen to give as great lengths of line and varieties of grade as possible. Each sewer had at its upper end a manhole about 4 ft. in diameter at the bottom. In place of flush-tanks these manholes were stopped up, the flushing water being released as desired through a 5-in. hole in a pine board placed over the end of the outlet pipe. The rate of discharge varied from 0.89 cu. ft. per sec. for a 4-ft. head to 11 ft. for a 6-ft. head. It was thought that these conditions approximated closely enough to those pertaining to the operation of flush tanks. No velocity measurements were made, but observations were taken at successive manholes below the one where the flush was made of the depth of the wave and its power to move gravel and other obstructions placed in the sewers. The paper contained diagrams showing the result of these tests, two of which are reproduced herewith, the grades in Fig. 2 being steeper than those in Fig. 1. The Green St. sewer, shown in Fig. 1, was practically clean and nearly dry, no house connections having been made. The Aurora St. sewer was very foul with sewage deposits and a vegetable growth.

The transporting power of the flushing waves was observed by small brickbats and gravel stones, painted different colors, so as to be easily recognized.

Early this year Mr. Ogden sent reply postal cards to officials in 150 cities with populations of from 10,000 to 60,000, asking them several questions bearing on the subject under discussion. About 80 replies were received, showing "how uncertain and vague is the knowledge on the subject, and how necessary are experiments and investigations."

From all the information available Mr. Ogden finally drew the following conclusions:

(1) Flushing of some sort is required at the upper ends of laterals, the frequency and the amount depending on the number of house connections, on the carefulness or prodigality in the use of water by the householder, on the grade and size of the sewer, on the character of its construction, and on a mysterious something which defies definition but which produces frequent accumulations in one line and does not affect another, apparently like the first.

(2) This variety in the conditions prevents any exact statement of a relation between the quantity of water which should be discharged from a flush-tank and the grade of a sewer, but it plainly indicates that the value of automatic flush-tanks lies in a general guarantee of insurance against accumulations in the upper part of the laterals, while periodic hand-flushing must be depended on only when in charge of a responsible, indefatigable and intelligent caretaker.

(3) Judging by the experience at Ithaca, and despite the statements of other engineers, it seems to the author that on grades of less than 1% automatic flush-tanks are an economic necessity, even where water has to be paid for, the added expense of frequent hand-flushing more than offsetting the possible discharge of flush-tanks when not absolutely necessary.

(4) The volume of water discharged should not be less than 40 cu. ft., and the effect of the flush can hardly be

This table shows that, using Kutter's formula, and taking n = 0.013, a 1% grade is required for a 6-in. pipe flowing half full at a velocity of 2½ ft. per sec. It also shows that the amount and depth of flow decrease together. The table is as follows:

Distance from dead end, ft.	Discharge, cu. ft. per sec.	Slope, ft. per foot.	Depth, flow, ins.
1,750	0.245	0.0103	3.00
1,500	0.210	0.0104	2.76
1,250	0.175	0.0123	2.25
1,000	0.140	0.0140	1.92
750	0.105	0.0174	1.50
500	0.070	0.0225	1.14
400	0.056	0.0256	1.08
300	0.042	0.0302	0.96
200	0.028	0.0342	0.72
100	0.014	0.0400	0.60

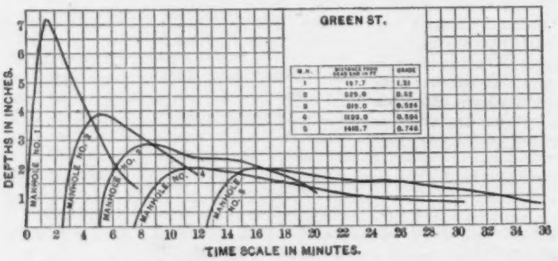


FIG. 1.—FORM OF FLUSHING WAVE IN GREEN ST. SEWER, ITHACA, N. Y.
(Volume of flush, 40 cu. ft.; curves are averages of three flushes.)

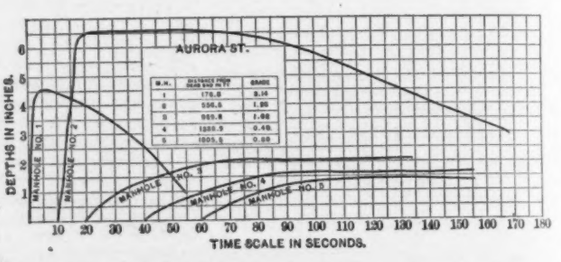


FIG. 2.—FORM OF FLUSHING WAVE IN AURORA ST. SEWER, ITHACA, N. Y.
(Volume of flush, 40 cu. ft.)

*See Trans. Am. Soc. C. E., vol. xxxiv., p. 223.

expected to reach more than 600 to 800 ft. Below this point accumulations may occur which must be removed by hand-flushing and carried on to a point where the sewage flow has the necessary transporting power.

(5) On flat lines and where obstructions occur below the influence of the flush-tank, a second flush-tank, placed about 800 ft. from the first, will be more effective than increasing the first tank to a capacity of three times its original discharge.

(6) The frequency of discharge should depend on the local conditions, but it is probable that the maximum interval depends on the practical working of the siphon, so that the usual prescription of once in 24 hours is a safe rule.

(7) If tanks are used on grades greater than 1%, 15 to 20 cu. ft. give as good results as larger amounts, with the same rule as to frequency of discharge.

(8) However, economy is best served on grades above 1% by omitting flush-tanks and resorting to periodic hand-flushing at such intervals as experience shows to be necessary on the different lines. In most cases semi-annual or quarterly flushings with a hose are sufficient.

(9) On grades greater than 3% flush-tanks are unnecessary, and their installation is a waste of money.

(10) Hand-flushing should be performed and tanks discharged at night, as a flow of even an inch in a sewer offers a large resistance to the flushing action, while with a pipe flowing half full the effect of a flush-tank is scarcely visible.

The discussion on the paper may be summarized as follows: Mr. Wm. B. Landreth, M. Am. Soc. C. E., sent a communication in which he stated that he had used flush tanks on both the separate and combined systems. As a result of observing the working of these tanks he arrived at no very different conclusions than those presented by Mr. Ogden. This was the only communicated discussion.

Mr. Rudolph Hering, M. Am. Soc. C. E., said the paper was a valuable one. European experience with flushing sewers dates back some fifty years, and the automatic flush tank has been used abroad since 1878. He thought Mr. Ogden's estimate of the cost of flush tanks unfair. Manholes must be provided in every case, and the flushing mechanism cost only $15 or $20 extra. The cost of the water consumed in flushing, 20 cts. per 1,000 gallons, might be all right where the waterworks are owned by a private company, operating under a liberal franchise, but in many cities the cost would not be more than half as great. The "mysterious something" mentioned in conclusion (1), Mr. Hering thought would lose its mystery if all the conditions could be known and analyzed. The statement that a 1-in. depth of flow of sewage would retard the flushing effect he thought was wrong. Mr. Hering, in conjunction with Mr. Jas. H. Fuertes, M. Am. Soc. C. E., showed some diagrams made by replotting those by Mr. Ogden in profile form.

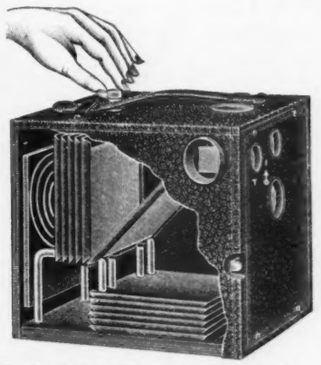
Mr. Fuertes said that the paper just read would correct some popular fallacies. Speaking of the functions of flushing, he said that the operation must first dislodge matter deposited in the sewers and then carry it along. The dislodging is done largely by the toe of the wave and the transporting by the full volume. Mr. Fuertes thought the extra cost of flushing assumed by Mr. Ogden was two or three times too great. He was not in accord with the author's conclusion (9), that "on grades greater than 3% flush tanks are unnecessary." In conclusion, he suggested that the subject might be pursued further with advantage at the hydraulic laboratory of Cornell University.

The discussion concluded with some remarks by one or two members on vegetable growths and mud deposits in sewers, instances being cited where these had been removed by flushing, meaning, evidently, by hose flushing under pressure.

A PHOTOGRAPH CAMERA WITH MAGAZINE FOR PLATES.

The application of photography to engineering work has become very extensive within recent years, and the camera is now very generally used on surveys, to show the progress of construction, to illustrate buildings, engines and machinery, and to record the results of accidents to trains or structures, etc. There are probably few engineers and railway offices which do not employ the camera more or less, and the manufacturers of photographic apparatus are thus finding a new and ever-increasing field for their appliances.

Undoubtedly the best results in photography can be obtained by the use of glass plates, but the inconvenience of renewing the plates in the field have led to extensive use of, for scientific work, the film cameras, having a long strip of sensitive film mounted on rollers. With such instruments, all that has to be done in the field is to set and release the shutter and turn the roller to expose a portion of unused film for the next picture. The above objections to the plate cameras, however, have been met by the introduction of a magazine plate camera, which is charged with a magazine having twelve plates, each plate being laid down out of the way when it is used by means



Sectional View of Magazine Plate Camera. Western Camera Mfg. Co., Makers.

of a button on the outside of the camera, as shown in the accompanying cut. When the twelve plates have been exposed, the camera is taken to a dark room, the magazine is withdrawn, and refilled with new plates. With such an instrument, it will be seen the operations are as simple as with a film camera, and it will often be unnecessary to carry an extra package of plates. This camera, styled the "Magazine Cyclone," is being introduced by the Western Camera Mfg. Co., of Chicago, Ill.

POWER CONSUMED IN OPERATING A CONDUIT ELECTRIC RAILWAY.

The January issue of the "School of Mines' Quarterly" contains a brief description of two tests of the Lenox Avenue Conduit Electric Railway, by G. F. Severs. This is of interest, giving, as it does, the power consumption of what may be considered the best type of conduit street railway yet devised, under two sets of working conditions.

As originally installed, the working pressure was maintained at about 300 volts. Since then the pressure has been raised, and at present the usual railway voltage of 500 is in use. The first test was made with the low voltage in February, 1897, at which time there was a light snow on the ground. The later test, made in May of the same year, the weather being clear, employed the higher voltage, otherwise the conditions were identical. The cars were equipped with two General Electric 800 motors and K$_2$ series parallel controllers.

The results obtained over the same section of track are as follows:

	February.		May.	
	First series.		Second series.	
	Maximum.	Average.	Maximum.	Average.
Voltage	410	323.7	540	475.1
Current	140	31.8	120	19.2
Watt-hours* ...	...	1,233	...	818

*Per car-mile.

Comparing the figures given, it will be noticed that the average current per car was reduced from 31.8 amperes to 19.2 amperes, or a saving of 12.6 amperes. As the transmission losses, or $C^2 R$ loss, of the feeders and conductors varies directly as the square of the current, the considerable saving of power is at once apparent. This put in terms of power consumed per car mile gave a saving of 385 watt-hours.

The trip south is nearly all up hill, the grade varying from 3 to 7%, and it was observed, as would be expected, that the trip averaged 944 watt-hours per car mile as against 752 on the return trip, which was down hill. This clearly brings out the point that the switches and feeders for a down-hill circuit can be made smaller and lighter than those for the up hill circuit, and thus a considerable saving in copper may be effected.

THE CONGO RAILWAY, 240 miles long, from Matadi to Stanley Pool, has now been finished by Belgian surveyors and Belgian capital. This railway is intended to carry traffic around the rapids in the Congo River, until now the chief obstacle in Central African commerce. Commodities of all kinds had to be carried around these rapids by men, and for several years past this traffic has been equal to about 100,000 back loads each season. It is said that there are 10,000 miles of waterway above the pool navigable for light-draft steamers.

A NEW SCHEME FOR CROSSING THE BRITISH Channel is proposed by M. Thouvenet le Boul, a member of the Technical Committee of the French Channel Bridge Co., an old but long quiescent organization. His plans include a bridge with the floor submerged about 50 ft. below low-water mark; upon the track on this bridge would roll a tower-like structure with its top above the water and operated by electrical power. This tower, or platform, would receive the ordinary railway trains by means of suitable connections on either side of the Straits of Dover. The plan, which is simply an amplification of the rolling bridge now used at St. Malo, in France, is estimated to cost $70,000,000, and the time required for construction is about five years. Three such rolling platforms, working only in daylight, would be sufficient for an annual traffic of 3,000,000 tons of merchandise and 2,000,000 passengers; and the promotors figure that this traffic would yield a net income of $10,000,000. The platform proposed would be about 500 ft. long and 50 ft. wide, supported by five steel pillars on each side, braced and resting on a submerged platform 100 ft. wide. Steam engines and dynamos on the upper platform would supply the motive power and transmit it to the submerged wheels. No particulars are given as to how the projectors would propose to build and lay and maintain tracks on a structure 50 ft. under water, nor as to how any such structure would withstand the rough seas and strong currents of the Channel.

THE NEW YORK SCIENTIFIC ALLIANCE, started seven years ago, is a confederation of some of the different scientific bodies of New York, and now includes the New York Academy of Sciences, Torrey Botanical Club, New York Microscopical Society, Linnæan Society of New York, American Mathematical Society, New York Mineralogical Club, the New York Section of the American Chemical Society, and the New York Entomological Society. In this Alliance each of the above eight organizations preserves its individuality and has its own officers. The purposes of the confederation were more fully explained at the late annual dinner, and the first important step towards the realization of its purposes was deemed to be a building owned by the Alliance and fitted for holding meetings, storing collections, providing laboratories for the encouragement of original chemical and physical research, and the inauguration of free lectures. It has been decided to raise the necessary funds by subscription, and Architect Robert W. Gibson has prepared plans of the building proposed. This building would be about 100 ft. square, and the lecture room would seat 1,000 persons. The estimated cost of land and building is $500,000. Mr. Charles F. Cox is the President of the Alliance, and Prof. N. L. Britton is the Secretary.

THE MARYLAND GEOLOGICAL COMMISSION, at its last semi-annual meeting at Johns Hopkins University, reported that the second volume of the survey reports was ready for the press. This volume will treat of the building and decorative stones of Maryland, by Prof. Geo. P. Merrill and Dr. Ed. B. Matthews; a history of Maryland cartography, by Mr. Henry Gannett, of the U. S. Geological Survey; the streams of Maryland, by Cleveland Abbe, Jr., and the second report upon magnetic work, by Dr. L. A. Bauer. The last Maryland legislature authorized the commission to prepare topographical maps of the state and to study the road problem. Prof. William Bullock Clark, of Johns Hopkins University, in charge as State Geologist, reports that under this bill arrangements could be made with the U. S. Geological Survey, by which a large area of the State would be surveyed during the present season. The $5,000 appropriated by the State for this purpose will secure the expenditure of $10,000 by the government. As to the road problem, it is the plan of the State Geologist to thoroughly investigate the distribution of the natural road building material, to test these materials for wearing and cementing qualities, and the present condition of existing roads will be examined and reported upon by an expert highway engineer. Estimates of cost for constructing and repairing roads will be prepared. The engineering problems will be in the hands of Mr. A. N. Johnson, lately connected with the Massachusetts Highway Commission.

THE WALTER WELLMAN ARCTIC EXPEDITION, according to press accounts, will sail from Tromsoe, Norway, on June 28, on the ice steamer "Fridtjof," for an 18-month trip in the Arctic regions. Cape Flora is to be made a supply station, and Mr. Wellman expects to pass the winter in huts somewhere between 82° and 83° North latitude, and to start for the Pole in the spring. He will also visit Franz Josef Land and search for Andree, who may be alive in that region. The Wellman expedition is said to be equipped by wealthy Americans, and it will carry everything necessary for a complete scientific journey of exploration. The following gentlemen go with him. Prof. James H. Gore, of Columbian University, Washington, D. C.; A. Harlan, of the U. S. Coast and Geodetic Survey; Dr. Edward Hofman, Grand Haven, Mich.; Lieut. E. B. Baldwin, of the U. S. Weather Bureau, and Meteorologist to the last Peary Expedition.

THE WEATHER BUREAU CIVIL SERVICE EXAMINations for observers, according to the "Manual of Examinations for the Classified Civil Service," Form 302, of January, 1895, require the following "weights" in the lines specified: Spelling, 5; arithmetic, 5; letter writing, 5; penmanship, 5; copying from plain copy, 5; copying from rough draught, 5; practical questions in meteorology, 40; an essay on a practical subject in meteorology, 20; geography of the United States, 10; total, 100. The examination for "Assistant in the Department of Agriculture" will embrace three scientific or technical subjects, according to the particular work of the bureau or department in which the applicant is supposed to serve. In the Weather Bureau meteorology comes first, with geography and general physics as minor subjects. The whole list of subjects and their respective "weights" is as follows: Orthography, 1.5; arithmetic, 2.5; letter writing, 2.5; penmanship, 1.5; copying, 2; applicant's past record or general training, 5; English composition, 5; major examination in one special scientific or technical subject, 50; minor examination in two required technical subjects, both together, 20; minor examination in additional elective subjects, such as languages, 10; total, 100. The next examinations occur in September and October, and the manual and special forms can be obtained by applying to the Civil Service Commissioners at Washington, D. C.

A TWO-SPEED MOVABLE SIDEWALK, of the Biot, Guyenet and de Mocomble type, is to be used for conveying visitors at the Paris Exposition. It differs from those of Chicago and Berlin in the reduction of the weight of the moving platform by spacing the driving wheels 127.5 ft. apart and using electricity as a motive power. The driving wheels are mounted in the bed of the track and impart motion to a central rail on the underside of the platform. Bearing wheels, spaced about 20 ft. apart under this rail also carry the platform, and the central rail supports one-half the total weight of the platform; small side wheels carry the other half on side tracks. This arrangement enables the platform, which is divided into sections and hinged, to pass around quite sharp curves. The high-speed platform, 4 ft. 3 ins. wide, is supposed to move at the rate of 6¼ miles per hour on a 35½-in. gage track; the slow platform is 31½ ins. wide, moves at half speed and runs on a 17¾-in. gage track. The whole structure will be elevated on girders carried by cast-iron columns, with stations about 656 ft. apart. The high-speed platform weighs 146 lbs. per lin. ft.; and with passengers, nearly 400 lbs. per ft. The slow-speed platform weighs about half this. The track will be about 2½ miles long; the initial motive power is figured at 472 HP., and the carrying capacity at 38,880 per hour.

RAMMED SOIL, as foundations, is being used at the site of the Paris Exposition of 1900, by Mr. Dulac, one of the contractors. In cases of made ground, or when the soil is loose, he uses a steam pile-driver and a conical ram, with which he rapidly makes deep holes, about 3 ft. apart. These holes are filled with some hard material after each blow, and this material is forced sideways as well as down. The process has been patented by Mr. Dulac, and he claims that by thus using a suitable quantity of hard material he can make a good foundation for his superstructure, and save 30 to 40% in cost, as compared with the usual excavation, and do it in one-third the time. In very soft, or water-soaked soil, he proposes to use ashes, mixed with a quick-setting cement; this lines the inside of the hole and produces a species of pipe for the passage of the ram. No material has to be excavated or carted away; and no bracing is needed. But he does not say whether he finally makes a continuous trench, or simply a succession of holes filled with hard material, as in the case of the old, so-called, "sand-piles."

DEATHS AMONG CAISSON-WORKERS have been investigated by Drs. R. Heller, Wilhelm Meyer and Hermann von Shrotter, and the results are contained in a paper in the "Centralblatt der Bauverwaltung," for Dec. 18, 1897, written by Mr. L. Brenecke. In 129 deaths among workers in compressed air, 38 men were divers and 91 caisson-workers. These doctors agree with the theory of Paul Bert, of Paris, that the danger lies, not in the high pressure, but in a too rapid reduction of pressure. This is shown by the fact that a sudden reduction from + 0.3 atmosphere to the normal has caused death; while a pressure of + 5.4 atmosphere was followed by no evil results when 3 hours 3 minutes were consumed in reducing this pressure. They agree that in all except exceptional cases, no deaths will occur if 2 minutes are allowed, in reduction, for every 0.1 atmosphere in excess of the normal pressure. They also propose a hospital air-lock where pressures of more than + 1.5 atmospheres are to be used, so that the sick may be treated under pressure. Workmen should be housed in barracks where they can be kept under medical control.

ASPHALT JOINTS FOR TERRA-COTTA PIPES are largely used in German cities, on the lines laid down by Mr. Lindley, of Frankfort-on-Main. A ring of rubber, or of canvas filled with cork shavings, is fixed around the spigot end, to hold the asphalt, and the latter is then poured in hot, after the pipes are put together. They cost about the same as a cement joint, for small sizes; but the claimed advantages over cement are less percolation, elasticity, resistance to acids and alkalies, and the ability to lay pipe in all weather. Pipes thus jointed can be rapidly separated by slightly heating them. The "Gesundheits-Ingenieur," for 1897, contains an article by Mr. A. Unna describing the detailed methods of making and the cost of these asphalt joints.

IMPORTANT LEGISLATION FOR THE RELIEF of the Patent Office has been passed by Congress. It directs the Commissioner of Patents to revise and perfect the classification, by subject matter, of all letters patent and printed publications in the office which constitute the field of search in examinations as to the novelty of an invention. It also authorizes the employment of an additional force in the office, not exceeding three principal examiners, two first assistant, two second, six third and four fourth assistant examiners, four first-class clerks, four copyists, six laborers, six assistant messengers and six messenger boys, the annual expense of this additional force not to exceed $62,800. It is expected that this act will relieve the present congestion of work in the office, which is now from four to seven months behind time.

THE ENERGY REQUIRED TO LIFT THE EARTH, which weighs approximately 6,000,000,000,000,000,000,000 long tons, one foot, according to Mr. J. A. Renie, is given in "Power" as follows:

It would require the power of a 10,000-HP. engine about 70,000,000,000 years to lift the earth 1 ft. in height, and to do this work, allowing 13 lbs. of water per HP., it would require about 10,000,000,000,000,000,000 gallons of water, or more than would be discharged at the mouth of the Mississippi River in 60,000 years. This would be enough water to cover the entire surface of the earth to a depth of about 300 ft.; to convert this water into steam, using good boilers, would require about 4,000,000,000,000,000 tons of coal; if this coal were loaded on cars of 20 tons each it would require 200,000,000,000,000 cars; if the cars were 3 ft. long and all coupled together in one train it would reach around the earth 45,000,000 times, and if it was running 25 miles per hour it would require 5,000,000 years for it to run the length of itself.

It might be added that as the Sun is about 98,000,000 miles from the Earth this train would extend from the Earth to the Sun 11,500 times. To accommodate the cars it would require a freight yard of about 3,000,000,000 sq. miles or an area about 1,000 times as large as the whole of the United States, exclusive of Alaska.

COMPRESSED AIR IS TO BE USED as the motive power of the 28th and 29th St. cross-town line of the Metropolitan Street Railway Co. in New York city. A contract has been made between the company and the American Air Power Co. for furnishing 20 cars, equipped with Hoadley-Knight air motors. The cars will be of the same external appearance as the Broadway cars. A new power house will be built on the property of the Metropolitan Company in West 23d St., opposite the Pennsylvania Ry. terminal. The air compressor, for which order has been placed, is of 1,000 HP. capacity, and is of the Ingersoll-Sergeant four-stage single-acting type, provided with intercoolers between each pair of cylinders, and a final cooler after the fourth stage cylinder. The air cylinders are to be vertical, and will be set underneath the engine, which is a vertical cross-compound condensing Reynolds-Corliss engine, built by the E. P. Allis Co., of Milwaukee. For several months past part of the power house at 146th St. and Lenox Ave. has been used by the Air Power Co. for experimental work. Several cars have been equipped with air motors there, and have been successfully run over the Lenox Ave. line.

BOOK REVIEWS.

MODEL ENGINES AND SMALL BOATS.—New Methods of Engine and Boiler Making, with a Chapter on Elementary Ship Design and Construction. By Nevil Monroe Hopkins. D. Van Nostrand Co., New York. Cloth; 12mo.; pp. 74; 50 illustrations. $1.25.

This little book may be useful for a boy or an amateur mechanic who has the ambition to build with his own hands a small boat with its toy engine and boiler driven by an alcohol lamp. The model engines are made without castings, sheet brass being used as the material. The boiler is also of sheet brass, held together with brass screws and solder. The tools needed are only those usually found in a boy's workshop.

TABLES OF PARABOLIC CURVES FOR THE USE OF RAILWAY ENGINEERS AND OTHERS.—By George T. Allen, Assoc. M. Inst. C. E. Spon & Chamberlain, New York. Cloth, 6½ x 4¼ in.; pp. 47. $1.50.

The author describes, in English and French, the use of the parabolic, or transition curve on railway and canal work. No time is spent in discussing theory; and all the text is devoted to describing how these tables are to be applied in practice. The tables themselves range from 40° to 90°, for the half-angle of intersection, and give the length of curve, tangent, radius at apex and the half-chord. While worked out in chains and links in the examples given, the method and tables apply as well to any other standard of length.

AMERICAN ELECTRICAL DIRECTORY AND BUYERS' MANUAL. First quarter, 1898.—E. L. Powers, Monadnock Block, Chicago, Ill. Pamph.; 6 x 9¼ ins.; pp. 136.

For any one engaged in the electrical manufacturing or supply business, or for any one purchasing electrical apparatus, if only in small amounts, this directory will be of considerable value, containing, as it does, a "Buyers' Finding List," in which, under the names of various electrical apparatus or parts of apparatus, are given the names of practically all the firms manufacturing these articles. This list occupies 21 pages, the remainder being devoted to a list of central lighting stations in the United States, Canada, Cuba and Mexico. This is arranged alphabetically, both as to states and cities, and includes enough information regarding the lighting plant or plants in each case to indicate, in a general way, what supplies would be wanted.

ROAD BOOK OF PENNSYLVANIA, EASTERN DIVISION.—Compiled by W. West Randall, Chairman, and Carl Hering, of the Road Book Committee of the Pennsylvania Division., L. A. W.; from reports furnished by members throughout the state. 1898. Flexible cloth, 7½ x 4½ ins.; pp. 103. Price: To Pennsylvania Division, 25 cts.; to members of other divisions, 35 cts. None sold to non-league members.

This is an excellent guide for wheelmen in the state covered. By easily recognized symbols, seven different types of roads are indicated, besides the railways, creeks and canals; and hills are shown by arrows with the number of arrows approximately giving the length and total rise of the hills. A similar book covers the Western Division of the state. In includes a full town index; routes of tours in other states; notes on routes; law for wheelmen, etc. The maps are all in one color, and thus cheaply made; and the chief criticism, that they are somewhat confused in parts, is met by the promise of a new edition on a larger scale, and with maps made by the wax-process. We understand that each member of the Pennsylvania Division of the League receives one copy gratis.

INTRODUCTORY COURSE IN MECHANICAL DRAWING. By J. C. Tracy, C. E., Instructor in the Sheffield Scientific School of Yale University, with a Chapter in Perspective, by E. H. Lockwood, M. E., Instructor in the Sheffield Scientific School. New York and London: Harper & Brothers. Cloth; 8 x 11 ins.; pp. 100, with 163 illustrations and 8 full-page plates. $2.00.

We quote the following from the preface:

This book is intended for beginners. Its aim is to prepare the student for a more extended course in any one of the special lines of drafting. The endeavor has been to make the book comprehensive enough for use in schools and colleges, and, at the same time, to have it meet the needs of the student who must study the subject with little if any help from a teacher.

The first portion of the book contains a list of problems to be undertaken by the student, constituting two distinct but parallel courses of 26 plates each. The author says that from 90 to 100 hours should be a sufficient time in which to complete either course. The problems begin with the simplest operations, such as drawing parallel lines, then follow in order problems in isometric, cabinet and orthographic projection, and in curves, intersections, shadows and perspective. Chapters then follow on selection of the outfit, use of instruments, working knowledge, isometric and cabinet projection, orthographic projection and its application, this subject occupying about half of the space in the book, and very brief chapters on perspective and working drawings, wisely omitting machine drawing and other advanced applications of mechanical drawing, but being thorough in its teaching of first principles, and in giving in pointed form all the working directions which the student is usually supposed to obtain in verbal instruction from his teacher. The illustrations are numerous and clear.

We can commend this work most heartily, both to the teacher in search of a good text-book for use in his classes and to the student attempting to become a mechanical draftsman by home study or by apprenticeship in the drafting rooms, where such knowledge as is contained in the pages of this book is only to be acquired by the slow process of experience. It is by all odds the best and most useful text-book on elementary mechanical drawing that has ever come to our notice.